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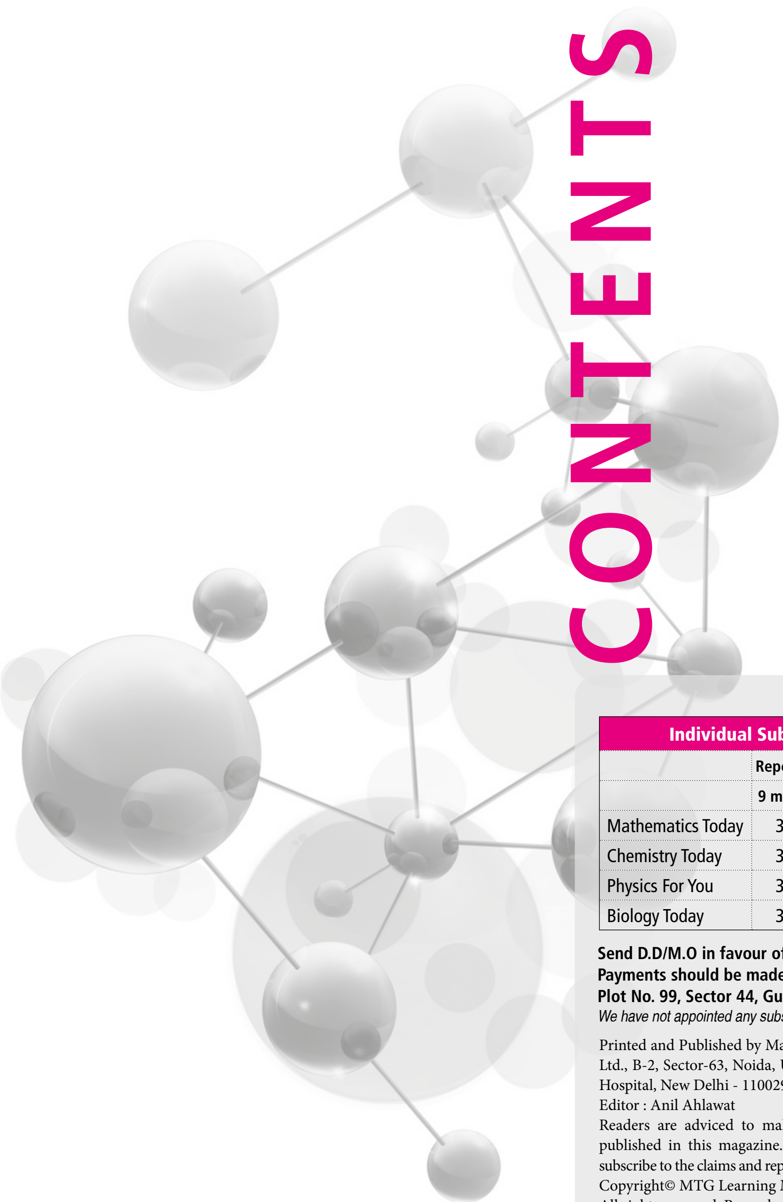
Managing Editor
Mahabir Singh

Editor
Anil Ahlawat

Corporate Office:
Plot 99, Sector 44 Institutional area, Gurgaon -122 003 (HR).
Tel : 0124-6601200 e-mail : info@mtg.in website : www.mtg.in

Regd. Office:
406, Taj Apartment, Near Safdarjung Hospital, New Delhi - 110029.



CONTENTS

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Class XI

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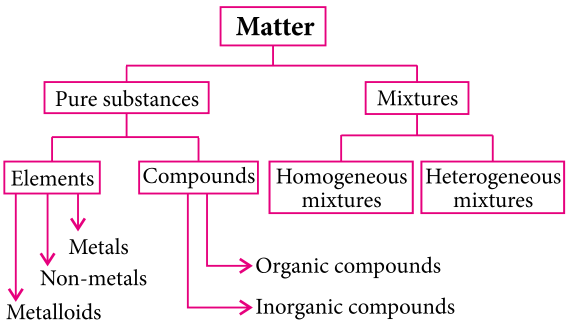
UNIT - 1 : Some Basic Concepts of Chemistry / Structure of Atom

SOME BASIC CONCEPTS OF CHEMISTRY

- Chemistry deals with the composition, structure and properties of matter which can be described and understood in terms of basic constituents of matter *i.e.*, *atoms* and *molecules*.
- Anything which has mass and occupies space is called *matter*.

Chemical Classification of Matter



Laws of Chemical Combination

- **Law of conservation of mass :** It states that during any physical or chemical change, total mass of products is equal to the total mass of reactants.

  e.g., $C + O_2 \longrightarrow CO_2$

  12 g 32 g 44 g

  Mass of CO_2 = Mass of C + Mass of O_2
- **Law of definite proportion :** It states that a compound always contains the same elements combined in the same definite proportion by weight. *e.g.*, water (H_2O) obtained from any source always contains 2 g of hydrogen in combination with 16 g of oxygen.
- **Law of multiple proportion :** It states that when two or more elements combine to form two or more compounds, the different weights of one of the elements which combine with the fixed weight of the other, bear a simple whole number ratio to one another.

  e.g., The ratio between the weights of oxygen in different compounds which combine with the same weight of N (14 parts) is

  8 : 16 : 24

  1 : 2 : 3

  N_2O NO N_2O_3
- **Law of reciprocal proportion :** It states that when two elements combine separately with a fixed mass of third element, then the ratio between their masses in which they combine will be either same or simple multiple of the ratio in which they combine with each other.
- **Gay Lussac's law of combining volumes :** It states that under similar conditions of temperature and pressure, whenever gases react together, the volumes of the reacting gases as well as products bear a simple whole number ratio.

Atomic Mass

- Atomic mass = $\dfrac{\text{Mass of one atom of the element}}{\frac{1}{12}\text{ mass of one atom of } ^{12}\text{C isotope}}$
- Number of gram atom or mole of atoms
  $= \dfrac{\text{Mass of element in gram}}{\text{Gram atomic mass}}$
- Atomic mass = Equivalent mass × Valency
- Atomic mass $= \dfrac{6.4}{\text{Specific heat}}$ (approx)

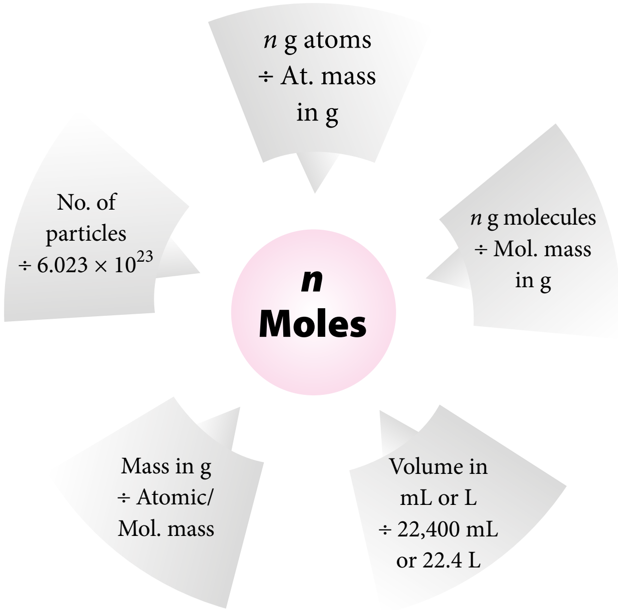
Molecular Mass

- Molecular mass
  $= \dfrac{\text{Mass of one molecule of a substance}}{\frac{1}{12} \times \text{Mass of one atom of } ^{12}\text{C isotope}}$
- Molecular mass = 2 × Vapour density

Equivalent Weight

- Equivalent weight of an element in a redox reaction
  $= \dfrac{\text{Atomic weight}}{\text{No. of electrons lost or gained by one atom of that element}}$
- Equivalent weight of an element
  $= \dfrac{\text{Atomic weight of the element}}{\text{Valency of the element}}$
- Equivalent weight of an acid
  $= \dfrac{\text{Molecular weight of the acid}}{\text{Basicity}}$
- Equivalent weight of a base
  $= \dfrac{\text{Molecular weight of the base}}{\text{Acidity}}$

Mole Concept



Determination of Chemical Formula

- Empirical formula gives the simple whole number ratio of the atoms of various elements present in one molecule of the compound.
- Molecular formula gives the actual number of atoms of various elements present in one molecule of the compound.
- Molecular formula = n (Empirical formula), where n = 1, 2, 3, ...

Stoichiometry

- In balanced chemical equation, the quantitative relationship between various reactants and products in terms of moles, masses, molecules and volumes is called stoichiometry. Stoichiometry is the Greek word meaning to measure an element. The coefficient of balanced chemical equation are called stoichiometric coefficients.
  For example :
  $$\underset{3\text{ moles}}{3SO_2} + \underset{2\text{ moles}}{2H_2S} \rightarrow \underset{2\text{ moles}}{2H_2O} + \underset{3\text{ moles}}{3S} + \underset{2\text{ moles}}{2O_2}$$
  3 moles of SO_2 react with 2 moles of H_2S to give 2 moles of water, 3 moles of sulphur and 2 moles of O_2.

Limiting Reagent

- The reactant which is completely consumed in the reaction and hence limits the amount of product formed is called limiting reagent.
- In case where there is a limiting reagent, the initial amount of the limiting reagent must be used to calculate the amount of product formed.

Reactions in Solution

- Normality = Number of gram equivalents of the solute/volume of the solution (in L)
- Molarity = Number of moles of the solute/volume of the solution (in L)
- No. of gram equivalents

$$=\frac{\text{Weight of the solute (in g)}}{\text{Equivalent weight of the solute}}$$

- No. of milliequivalents

$$=\frac{\text{Weight of solute}}{\text{Equivalent weight of solute}}\times 1000$$

- No. of moles $=\dfrac{\text{Weight of the solute (in g)}}{\text{Molecular weight of the solute}}$
- Molality = Number of moles of solute/Weight of solvent (in kg)
- Normality equation or molarity equation

$N_1 \times V_1 = N_2 \times V_2$

$M_1 \times V_1 = M_2 \times V_2$

- When the solutions of two substances (an acid and a base or an oxidizing and a reducing substance) react completely, we apply normality equation *viz.*

$$\underset{\text{(Solution 1)}}{N_1 \times V_1} = \underset{\text{(Solution 2)}}{N_2 \times V_2}$$

- In terms of molarity equation, for the reaction

$n_1 A + n_2 B \longrightarrow$ Products, we apply

$$\frac{M_1V_1}{\underset{(A)}{n_1}} = \frac{M_2V_2}{\underset{(B)}{n_2}}$$

Relations between Different Concentration Units

Concentration units	Relation
Molarity and Normality	$M \times$ Mol. mass of solute $= N \times$ Eq. mass of solute
Molarity and Mass percent	$M = \dfrac{\% \times d \times 10}{\text{Mol. mass}}$
Molarity and Molality	$m = \dfrac{100 \times M}{1000 \times d_{soln} - M \times GMM_{solute}}$

STRUCTURE OF ATOM

- Dalton's atomic theory proposed that matter is composed of small, indivisible particles called atoms.
- However, atoms are further composed of fundamental particles *i.e.*, electrons, protons and neutrons.

Properties of Electron, Proton and Neutron

Properties	Electron, *e*	Proton, *p*	Neutron, *n*
Mass	9.101×10^{-31} kg	1.67262×10^{-27} kg	1.67495×10^{-27} kg
Charge	-1.6022×10^{-19} C	$+1.6022 \times 10^{-19}$ C	0
Mass relative to the electron	1	1836	1839
Spin	1/2	1/2	1/2
Charge relative to the proton	–1	+1	0
Discovery	J. J. Thomson	Goldstein	Chadwick

Some Important Terms

- **Atomic number :** It is the number of protons present in the nucleus of an atom.
- **Mass number :** It is the total number of protons and neutrons (called nucleons) in an atom.

Term	Description	Examples
Isotopes	Different atoms of same element having same atomic number but different mass numbers.	${}^1_1H, {}^2_1H, {}^3_1H$; ${}^{35}_{17}Cl, {}^{37}_{17}Cl$
Isobars	Atoms of different elements having same mass number but different atomic numbers.	${}^{40}_{18}Ar, {}^{40}_{19}K, {}^{40}_{20}Ca$
Isotones	Atoms of different elements containing same number of neutrons.	${}^{14}_6C, {}^{15}_7N, {}^{16}_8O$
Isodiaphers	Atoms having same isotopic number (*i.e.*, no. of neutrons – no. of protons = same)	${}^{235}_{92}U, {}^{231}_{90}Th$
Isosters	Molecules having same number of atoms and electrons.	CO_2, N_2O
Isoelectronics	Those species which have same number of electrons.	Na^+, Mg^{2+}, F^-, Ne

Atomic Models

Thomson Model of Atom

J.J. Thomson proposed that, positive charge is spread over a sphere of radius ≈ 10^{-8} cm and electrons are embedded in it. This model explains the electrical neutrality of atom but not the other observations like spectra and α-scattering experiment.

Rutherford's Model of Atom

Rutherford proposed that, the nucleus of atom is hard, dense core and consists of protons while electrons revolve around the nucleus. It could not explain the line spectra of elements.

Bohr's Model of Atom

- Atom consists of a small, heavy and positively charged nucleus in centre, and electrons revolve around the nucleus in fixed paths called orbits.
- The electron can revolve only in those orbits whose angular momentum is an integral multiple of $h/2\pi$ *i.e.*,
  $mvr = \frac{nh}{2\pi}, n = 1, 2, 3, ...$
- Energy of an electron in the orbit does not change with time.
- When elelctron jumps from one level to another, energy is either emitted or absorbed.
  The energy difference between two states is given by
  $\Delta E = E_2 - E_1$
  As the distance of the orbits increases from the nucleus, the energy gap goes on decreasing, *i.e.*,
  $E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > ....$
- **Derivations from Bohr's Theory (for n^{th} orbit)**

	For hydrogen	For H– like particles
Energy (E_n)	$\frac{-1312}{n^2}$ kJ/mol	$\frac{-1312\,Z^2}{n^2}$ kJ/mol
Radius (r_n)	$0.529 \times n^2$ Å	$\frac{0.529\,n^2}{Z}$ Å
Speed (v_n)	$\frac{2.18\times10^8}{n}$ cm sec^{-1}	$\frac{2.18\times10^8}{n}\times Z$ cm sec^{-1}

Drawbacks of Bohr's Model

- Fails to explain electronic repulsions in multielectronic atoms.
- Does not support to the assumption,
  $mvr = \frac{nh}{2\pi}$
- Does not explain Stark effect and Zeeman effect.
- Does not explain the distribution of electrons in orbits.
- Against de-Broglie and Heisenberg's uncertainty principle.

Nature of Electromagnetic Radiations

- **Electromagnetic wave theory :** Energy is emitted continuously from any source in the form of radiations travelling in the form of waves and associated with electric and magnetic fields, oscillating perpendicular to each other and to the direction of radiations.
- All electromagnetic radiations have wave characteristics and do not require any medium for their propagation.
- The arrangement of various radiations in the decreasing order of their frequencies or increasing order of their wavelengths is called electromagnetic spectrum.

Cosmic rays, γ-rays, X-rays, UV rays, visible, IR, microwaves, radiowaves

$\xrightarrow{\text{Decreasing frequency}}$

Atomic Spectra of Hydrogen

- Atomic spectra represent the radiation or energy absorbed or emitted by an atom.
- **Rydberg formula :** $\bar{v} = \frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) Z^2$

where, R_H is Rydberg constant and has a value equal to 109,677 cm^{-1}.

- Radiations emitted by hydrogen in discharge tube experiments when passed through prism gives five series of lines named after the researchers.

	Name of series	Wavelength	n_1	n_2	Region
1.	Lyman	$\frac{1}{\lambda} = R_H \left[\frac{1}{1^2} - \frac{1}{n^2} \right]$	1	$n > 1$	UV
2.	Balmer	$\frac{1}{\lambda} = R_H \left[\frac{1}{2^2} - \frac{1}{n^2} \right]$	2	$n > 2$	Visible
3.	Paschen	$\frac{1}{\lambda} = R_H \left[\frac{1}{3^2} - \frac{1}{n^2} \right]$	3	$n > 3$	IR
4.	Brackett	$\frac{1}{\lambda} = R_H \left[\frac{1}{4^2} - \frac{1}{n^2} \right]$	4	$n > 4$	IR
5.	Pfund	$\frac{1}{\lambda} = R_H \left[\frac{1}{5^2} - \frac{1}{n^2} \right]$	5	$n > 5$	far IR
6.	Humphrey	$\frac{1}{\lambda} = R_H \left[\frac{1}{6^2} - \frac{1}{n^2} \right]$	6	$n > 6$	far-far IR

Towards Quantum Mechanical Model of the Atom

Dual Behaviour of Matter

- Every material particle in motion has dual nature *i.e.*, particle nature and wave nature and the relation between them is called de-Broglie relation.

Wavelength of wave $(\lambda) = \frac{h}{mv}$

Heisenberg's Uncertainty Principle

- According to Heisenberg's uncertainty principle, it is impossible to determine simultaneously the exact position and exact momentum (or velocity) of an electron.

$\Delta x \times \Delta p \geq \frac{h}{4\pi}$

Quantum or Wave Mechanical Model of Atom

- Quantum mechanics developed by Erwin Schrodinger is based on the wave motion associated with the particles.
- Schrodinger wave equation : $\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$
- The wave function ψ for an electron in an atom has no physical significance as such but ψ^2 gives the intensity of electron wave at that point or the probability of finding the electron at that point.
- An atomic orbital may be defined as three dimensional space around the nucleus where the probability of finding an electron is maximum (upto 90-95%).

Quantum Numbers

Principal quantum number, n : It corresponds to the main energy level or shell in which the electron is present.

The value of n :	1	2	3	4
Corresponding shell :	K	L	M	N

Azimuthal quantum number, l : It gives the orbital angular momentum and corresponds to the subshell in a given principal energy shell.

$l = 0, 1, 2, 3, ..., (n - 1)$

The various subshells are designated by the letters s, p, d, f.

The value of l :	0	1	2	3
Designation :	s	p	d	f

Spin quantum number, m_s : It corresponds to the direction of electron spin in each orbital.

m_s can have only two values, *i.e.*, $\pm 1/2$, represented as $\uparrow$ and $\downarrow$.

Magnetic quantum number, m_l : It describes the behaviour of an electron in magnetic field and it corresponds to the number of orbitals in a subshell.

$m_l = - l$ to 0 to $+l = (2l + 1)$ values.

Subshell :	s	p	d	f
No. of orbitals :	1	3	5	7

Rules for Distribution of Electrons

Rules

Aufbau Principle

Orbitals are filled in the order of increasing energy.
Lower $(n + l)$ value, lower is the energy. For same $(n + l)$ value, lower n value has lower energy.

Pauli Exclusion Principle

An orbital can accommodate maximum of two electrons and the electrons must have opposite spins.

Hund's Rule of Maximum Multiplicity

Pairing of electrons does not occur in orbitals of the same energy until each of them is singly filled.

SPEED PRACTICE

1. The equivalent weight of an acid is equal to
   (a) molecular weight/acidity
   (b) molecular weight/basicity
   (c) molecular weight × basicity
   (d) molecular weight × acidity.

2. It is known that atom contains protons, neutrons and electrons. If the mass of neutron is assumed to half of its original value whereas that of proton is assumed to be twice of its original value then the atomic mass of ${}^{14}_{6}C$ will be
   (a) same (b) 14.28% less
   (c) 14.28% more (d) 28.56% less

3. A light source of wavelength λ, illuminates a metal and ejects photo-electrons with $(K.E.)_{max}$ = 1 eV. Another light source of wavelength $\frac{\lambda}{3}$, ejects photo-electrons from same metal with $(K.E.)_{max}$ = 4 eV. Find the value of work function.
   (a) 1 eV (b) 2 eV
   (c) 0.5 eV (d) None of these

4. The kinetic energy of an electron in n^{th} of a single electron species of atomic number Z is $13.6\frac{Z^2}{n^2}$ eV .

The potential energy of this electron in the same situation is

(a) $-13.6\dfrac{Z^2}{n^2}$ eV (b) $-6.8\dfrac{Z^2}{n^2}$ eV

(c) $-27.2\dfrac{Z^2}{n^2}$ eV (d) $+27.2\dfrac{Z^2}{n^2}$ eV

5. A boy drinks 500 mL of 9% glucose solution. The number of glucose molecules he has consumed are
(a) 0.5×10^{23} (b) 1.0×10^{23}
(c) 1.5×10^{23} (d) 2.0×10^{23}

6. A mixture of O_2 and gas "*Y*" (mol. mass 80) in the mole ratio $a:b$ has a mean molecular mass 40. What would be the mean molecular mass if the gases are mixed in the ratio $b:a$ under identical conditions?
(a) 40 (b) 48 (c) 62 (d) 72

7. Two oxides of a metal contain 27.6% and 30% of oxygen respectively. If the formula of the 1st oxide is M_3O_4, the formula of the 2nd oxide is
(a) MO (b) M_2O_3
(c) MO_2 (d) M_3O_2

8. In any subshell, the maximum number of electrons having same value of spin quantum number is
(a) $\sqrt{l(l+1)}$ (b) $l + 2$
(c) $2l + 1$ (d) $4l + 2$

9. The limiting line in Balmer series will have a frequency of
(a) 6.22×10^{15} s^{-1} (b) 7.22×10^{14} s^{-1}
(c) 8.22×10^{14} s^{-1} (d) 9.22×10^{14} s^{-1}

10. Which of the following statements is correct?
(a) 1 mole of electrons weigh 5.48 mg.
(b) 1 mole of electrons weigh 5.48 kg.
(c) 1 mole of electtons weigh 0.548 mg.
(d) 1 mole of electrons has 1.6×10^{-19} C of charge.

11. 0.24 g of a volatile substance displaced 53.78 mL of air at STP. The molecular weight of the substance is
(a) 24 g (b) 53.78 g
(c) 50 g (d) 100 g

12. If the radius of first orbit of H-atom is a_0, then de-Broglie wavelength of electron in 4th orbit is
(a) $2\pi a_0$ (b) $16a_0$
(c) $a_0/4$ (d) $8\pi a_0$

13. The energy of second Bohr's orbit of hydrogen atom is –328 kJ mol^{-1}. The energy of the third Bohr's orbit of He^+ is
(a) –583.11 kJ mol^{-1} (b) –853.11 kJ mol^{-1}
(c) –145.78 kJ mol^{-1} (d) –511.83 kJ mol^{-1}

14. The total number of orbitals in a shell with principal quantum number n is
(a) $2n$ (b) $2n^2$ (c) n^2 (d) $n + 1$

15. Density of a 2.05 M solution of acetic acid in water is 1.02 g/mL. The molality of the solution is
(a) 3.28 mol kg^{-1} (b) 2.28 mol kg^{-1}
(c) 0.44 mol kg^{-1} (d) 1.14 mol kg^{-1}

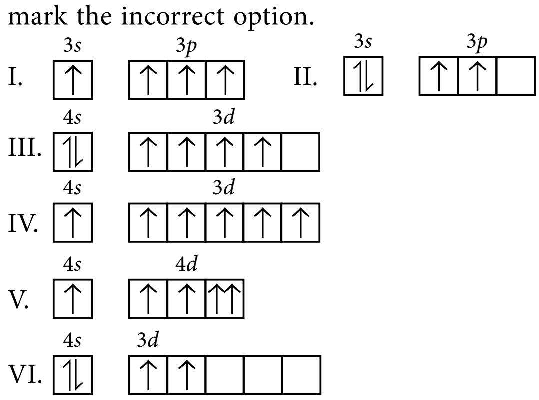
16. If each O-atom has two equivalents, volume of one equivalent of O_2 gas at STP is
(a) 22.4 L (b) 11.2 L
(c) 5.6 L (d) 44.8 L

17. Calculate the wavelength for the shortest wavelength transition in the Balmer series of atomic hydrogen.
(a) 27419.25 cm^{-1} (b) 2314.59 cm^{-1}
(c) 109677 cm^{-1} (d) 54838.5 cm^{-1}

18. Suppose two elements X and Y combine to form two compounds XY_2 and X_2Y_3. 0.05 mole of XY_2 weigh 5 g while 3.011×10^{23} molecules of X_2Y_3 weigh 85 g. The atomic masses of X and Y are respectively
(a) 20, 30 (b) 30, 40 (c) 40, 30 (d) 80, 60

19. If H-atom is supplied with 12.1 eV energy and electron returns to the ground state after excitation the number of spectral lines in Balmer series would be (use energy of ground state of H-atom = –13.6 eV)
(a) 1 (b) 2 (c) 3 (d) 4

20. Consider the following six electronic configurations (remaining inner orbitals are completely filled) and mark the incorrect option.



(a) Stability order : II > I > IV > III
(b) Order of spin multiplicity : IV > III = I > II
(c) V does not violate all the three rules of electronic configuration.
(d) If VI represents A and when A^+ kept near a magnet it acts as paramagnetic substance.

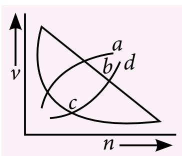
21. A mixture containing 1 mole each of $NaHCO_3$, Li_2CO_3 and Na_2CO_3 is heated strongly, CO_2 formed in this process will be
(a) 3.0 mol (b) 2.5 mol
(c) 1.0 mol (d) 1.5 mol

22. The atomic number of Ni and Cu are 28 and 29 respectively. The electronic configuration $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}$ represents
(a) Cu^+ (b) Cu^{2+} (c) Ni^{2+} (d) Ni

23. In the given reaction,
$2H_2O_{2(l)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$
100 mL of 'X' molar H_2O_2 gives 3 L of $O_{2(g)}$ under the condition when 1 mole occupies 24 L. The value of 'X' is
(a) 2.5 (b) 1.0 (c) 0.5 (d) 0.25

24. A 350 mL sample of ammonia at 1.00 bar and 27 °C is absorbed by water to form 500 mL of solution at that temperature and pressure. Molar concentration of ammonia is
(a) 0.28 M (b) 0.02 M
(c) 2.8 M (d) 0.014 M

25. Which of the following curves may represent the speed of the electron in a hydrogen atom as a function of the principal quantum number n?



(a) d (b) c (c) b (d) a

SOLUTIONS

1. (b): Equivalent weight of acid

$$= \frac{\text{Mol. wt. of acid}}{\text{Basicity}}$$

2. (c) : Number of protons in $_6C^{14} = 6$

Number of neutrons in $_6C^{14} = 8$

Given new atomic mass of $_6C^{14} = 12 + 4 = 16$

(As the mass of e^- is negligible as compared to neutron and proton)

$$\% \text{ increase in mass} = \frac{16-14}{14} \times 100 = 14.28$$

3. (c) : $\dfrac{hc}{\lambda} = 1 + \phi$ ...(i)

$3 \times \dfrac{hc}{\lambda} = 4 + \phi$ ...(ii)

From eq. (i) and (ii), $\phi = 0.5$ eV

4. (c) : Potential energy $= -2 \times K.E. = -2 \times 13.6 \dfrac{Z^2}{n^2}$

$$= -27.2 \frac{Z^2}{n^2} \text{ eV}$$

5. (c) : 100 mL solution contains 9 g glucose

∴ 500 mL solution contains

$$= \frac{9 \times 500}{100} = 45 \text{ g glucose}$$

Number of molecules in 180 g glucose $= 6.023 \times 10^{23}$

∴ Number of molecules in 45 g glucose

$$= \frac{6.023 \times 10^{23} \times 45}{180} = 1.5 \times 10^{23}$$

6. (d): Let mole fraction of O_2 is x.

$40 = 32 \times x + 80\,(1 - x)$

or $x = 5/6$

$a : b = x : (1 - x) = \dfrac{5}{6} : \dfrac{1}{6}$

When ratio is changed,

$$M_{\text{mixture}} = 32 \times \frac{1}{6} + 80 \times \frac{5}{6} = 72$$

7. (b): For 1st oxide : Let atomic weight of metal M is A. For M_3O_4

$$\frac{16 \times 4}{16 \times 4 + 3A} \times 100 = 27.6 \Rightarrow A = 56$$

For 2nd oxide :

Moles of $M = \dfrac{70}{56} = 1.25$, Moles of O $= \dfrac{30}{16} = 1.875$

$M : O = 1.25 : 1.875 = 1 : 1.5 = 2 : 3$

Formula is M_2O_3.

8. (c) : Maximum number of electrons with same spin quantum number is equal to maximum number of orbitals, *i.e.*, $(2l + 1)$.

9. (c) : The limiting line of Balmer series refers to the transition of electron from ∞ to 2nd orbit

$\upsilon = c.\bar{v}$

$$= 3 \times 10^{10} \times 109677 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

$$= 3.29 \times 10^{15} \left(\frac{1}{2^2} - 0 \right) \sec^{-1} \qquad (\because n_1 = 2, n_2 = \infty)$$

$= 8.22 \times 10^{14}$ sec^{-1}

10. (c) : 1 mole of electrons weighs

$= 9.1 \times 10^{-31} \times 6.023 \times 10^{23}$ kg

$= 54.8 \times 10^{-8}$ kg $= 54.8 \times 10^{-5}$ g

$= 0.548$ mg

11. (d): Molecular weight $= \dfrac{w}{V_{STP}} \times 22400$

$= \dfrac{0.24}{53.78} \times 22400 = 99.96 \approx 100$ g

12. (d): $r_n = a_0 \times n^2, \quad r_4 = a_0 \times 4^2 = 16a_0$

$$mv = 4 \times \frac{h}{2\pi r_4} = \frac{4h}{2\pi \times 16a_0} = \frac{h}{8\pi a_0}$$

As $\lambda = \dfrac{h}{mv}$

$\therefore \quad \lambda = 8\pi a_0$

13. (c) : $E_n = \dfrac{E_1}{n^2} \Rightarrow E_1 = 2^2 \times (-328)$

$= -4 \times 328$ kJ mol^{-1}

Energy of 3rd shell, $E_3 = \dfrac{E_1}{9} = -\dfrac{4 \times 328}{9}$

$= -145.78$ kJ mol^{-1}

14. (c) : Number of orbitals in a shell $= n^2$

15. (b): Molality $= \dfrac{1000M}{1000d - M \times M_B}$

$= \dfrac{1000 \times 2.05}{1000 \times 1.02 - 2.05 \times 60}$

$= \dfrac{2050}{1020 - 123} = \dfrac{2050}{897} = 2.285$ mol kg^{-1}

16. (c) : 1 O-atom $\equiv$ 2 equivalents of oxygen (given)

2 O-atoms $\equiv$ 4 equivalents of oxygen

1 mole of $O_2 \equiv 22.4$ L at STP

1 equivalent of $O_2 \equiv \dfrac{22.4}{4}$ L $= 5.6$ L

17. (a) : $\dfrac{1}{\lambda} = R_H\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

$= 109677\ (1/4 - 0) = \dfrac{109677}{4} = 27419.25$ cm^{-1}

18. (c) : Mol. mass of $XY_2 = \dfrac{5}{0.05} = 100$

Mol. mass of $X_2Y_3 = \dfrac{85}{3.011 \times 10^{23}} \times N_A = 170$

Let molar mass of X and Y are a and b respectively.

$\therefore \quad a + 2b = 100$

$2a + 3b = 170;$

$a = 40; b = 30$

19. (a) : New energy $= -13.6 + 12.1 = -1.5$ eV

$$E_n = \frac{-13.6}{n^2} \Rightarrow n^2 = \frac{-13.6}{-1.5} = 9 \Rightarrow n = 3$$

Number of spectral lines in Balmer series for $3 \rightarrow 2$ transition would be one only.

20. (c) : V violated Hund's rule.

21. (d): $\underset{1\ \text{mol}}{Li_2CO_3} \xrightarrow{\Delta} Li_2O + \underset{1\ \text{mol}}{CO_2}$

$Na_2CO_3 \xrightarrow{\Delta}$ No reaction

$\underset{\substack{2\ \text{mol} \\ 1\ \text{mol}}}{2NaHCO_3} \xrightarrow{\Delta} Na_2CO_3 + \underset{\substack{1\ \text{mol} \\ 0.5\ \text{mol}}}{CO_2} + H_2O$

Total moles of $CO_2 = 1 + 0.5 = 1.5$ mol

22. (a)

23. (a) : $\underset{(2\ \text{moles})}{2H_2O_{2(l)}} \longrightarrow 2H_2O_{(l)} + \underset{(1\ \text{mole} = 24\ \text{L})}{O_{2(g)}}$

Under given conditions, 1 mole occupies 24 L of O_2.

24 L of O_2 is formed from 2 moles of H_2O_2

3 L of O_2 is formed from $= \dfrac{2 \times 3}{24} = 0.25$ moles of H_2O_2 in 100 mL of solution

Thus, molarity of $H_2O_2 = \dfrac{0.25 \times 1000}{100} = 2.5$ mol L^{-1}

24. (b): Moles of ammonia $= \dfrac{PV}{RT} = \dfrac{1 \times 0.350}{0.082 \times 300}$

$= 0.01$ mol

Molar concentration $= \dfrac{\text{Number of moles}}{\text{Volume (in L)}} = \dfrac{0.01}{0.500}$

$= 0.02$ M

25. (b): $v_n \propto \dfrac{Z}{n}$

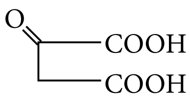
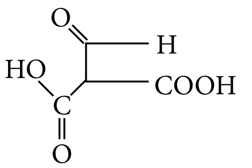
where v_n is the velocity of electron in n^{th} orbit.

Class XI

Be JEE READY

with exclusive and brain storming MCQs

Practicing these MCQs helps to strengthen your concepts and give you extra edge in your JEE preparation

1.  and  are

(a) identical compounds (b) positional isomers
(c) functional isomers (d) chain isomers.

2. Several acids are listed below with their respective equilibrium constants :

$HF_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + F^-_{(aq)}$; $K_a = 7.2 \times 10^{-4}$

$HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + S^{2-}_{(aq)}$; $K_a = 1.3 \times 10^{-11}$

$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$; $K_a = 1.8 \times 10^{-5}$

Which is the strongest acid and which acid has the strongest conjugate base?

(a) HF and HF (b) HF and HS^-
(c) HS^- and CH_3COOH (d) HS^- and HF

3. If you are initially provided with 224 g of pure chromite ore and 169.6 g of sodium carbonate, then the minimum volume of air required at NTP to consume at least one of the reactant completely, if air contains 20% by volume of oxygen gas, is

(a) 156.8 L (b) 196 L
(c) 31.36 L (d) 168 L

4. Ethanol can undergo decomposition to form two sets of products.

$C_2H_5OH_{(g)} \xrightarrow{1} C_2H_{4(g)} + H_2O_{(g)}$; $\Delta H° = 45.54$ kJ

$C_2H_5OH_{(g)} \xrightarrow{2} CH_3CHO_{(g)} + H_{2(g)}$; $\Delta H° = 68.91$ kJ

If the molar ratio of C_2H_4 to CH_3CHO is 8 : 1 in a set of product gases, then the energy involved in the decomposition of 1 mole of ethanol is

(a) 114.45 kJ (b) 48.137 kJ
(c) 23.37 kJ (d) 57.22 kJ.

5. The hybridisation of nitrogen in trimethyl amine and formamide is

(a) sp^2, sp^3 (b) sp^3, sp^2
(c) sp^3, sp^3 (d) sp^2, sp

6. Two samples of water *A* and *B* have concentrations 16.2 ppm of $Ca(HCO_3)_2$ and 13.6 ppm of $CaCl_2$ respectively. Then

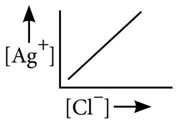
(a) hardness is more in sample '*B*' than in '*A*'
(b) hardness is more in sample '*A*' than in '*B*'
(c) hardness in sample '*A*' is twice that of the sample '*B*'
(d) hardness is same in both cases.

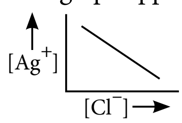
7. A sudden jump between the values of second and third ionization energies of an element would be associated with the electronic configuration

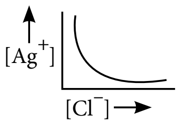
(a) $1s^2\,2s^2\,2p^6\,3s^1$ (b) $1s^2\,2s^2\,2p^6\,3s^2 3p^1$
(c) $1s^2\,2s^2\,2p^6\,3s^2\,3p^2$ (d) $1s^2\,2s^2\,2p^6\,3s^2$

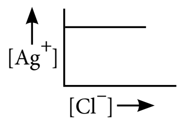
8. X and Y are metal nitrates. X on heating liberates O_2 but Y on heating liberates NO_2 and O_2. X and Y are respectively
(a) $NaNO_3$, KNO_3 (b) $LiNO_3$, $Mg(NO_3)_2$
(c) $NaNO_3$, $Mg(NO_3)_2$ (d) $Mg(NO_3)_2$, $NaNO_3$

9. In a saturated solution of AgCl, NaCl is added gradually. The concentration of Ag^+ is plotted against the concentration of Cl^-. The graph appears as

(a) 

(b) 

(c) 

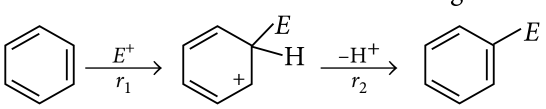
(d) 

10. Which of the following does not indicate high level of pollutants or the toxic substances?
(I) High DO value (II) High COD value
(III) High BOD value (IV) High TLV
(a) I, II and II only (b) I and IV only
(c) II and III only (d) III and IV only

11. In the following sequence of reactions :
$2M + N_2 \longrightarrow 2MN$ (very hard substance)
$MN + H_2O \longrightarrow$ Acid + pungent smelling gas
acid is
(a) HNO_2 (b) H_3BO_3
(c) HNO_3
(d) both HNO_3 and H_3BO_3

12. The pH of a solution of H_2O_2 is 6.0. Some chlorine gas is bubbled into this solution. Which of the following is correct?
(a) Hydrogen gas is liberated.
(b) The pH of resultant solution becomes 8.0.
(c) The pH of resultant solution becomes less than 6.0 and oxygen gas is liberated.
(d) Cl_2O is formed in the resultant solution.

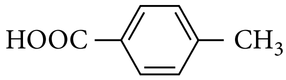
13. Which statement is true for the following reaction?

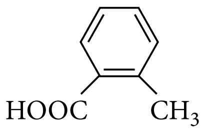


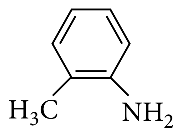
(I) (II) (III)

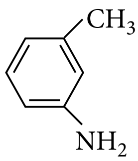
(a) C_6H_6 and C_6D_6 react with almost same rate for most of the electrophiles.
(b) II is an aromatic species.
(c) Rate of first step (r_1)is faster than rate of second step (r_2) in most of aromatic electrophilic substitution reactions.
(d) Electrophilic addition is more favoured than electrophilic substitution in benzene.

14. When $KMnO_4$ acts as an oxidising agent and ultimately forms MnO_4^{2-}, MnO_2, Mn_2O_3, and Mn^{2+}, then the number of electrons transferred in each case is
(a) 2, 3, 1, 5 (b) 4, 5, 3, 7
(c) 1, 3, 4, 5 (d) 3, 5, 7, 1

15. The compounds in which the $-CH_3$ group causing increase in acid strength and decrease in basic strength are respectively
(1) CH_3–COOH
(2) 

(3) 

(4) 

(5) 

(a) 3 and 5 (b) 1 and 5
(c) 3 and 4 (d) 2 and 5

SOLUTIONS

1. **(c) :** Both compounds have different functional group. I[st] has ketone group but II[nd] have aldehyde group.

2. **(b) :** Higher is the value of K_a, Stronger is the acids. Hence, here, HF is the strongest acid while HS^- is the weakest. Weakest acid (HS^-) has the strongest conjugate base.

3. **(a) :** $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2\,Fe_2O_3 + 8CO_2$

$\frac{224}{224} = 1$ mole; $\frac{169.6}{106} = 1.6$ mole

Moles of O_2 required for complete consumption of $FeCr_2O_4 = \frac{7}{4} = 1.75$ moles

Moles of O_2 required for complete consumption of $Na_2CO_3 = \frac{1.6 \times 7}{8} = 1.4$ moles

Here Na_2CO_3 is the limiting reactant

∴ Minimum volume of O_2 required

$= 1.4 \times 22.4 = 31.36$ L

∴ Minimum volume of air required

$= \frac{100}{20} \times 31.36 = 156.8$ L

4. **(b) :** $\Delta_r H = \frac{8}{9} \times 45.54 + \frac{1}{9} \times 68.91 = 48.137$ kJ

5. **(b) :** In amine the nitrogen atom is sp^3 hybridised and in amide the nitrogen atom is sp^2 hybridised.

6. **(a)**

7. **(d) :** There is a sudden jump in the value of *IE* when there is change of principal energy level.

8. **(c) :** $\underset{(X)}{2NaNO_3} \xrightarrow{\Delta} 2NaNO_2 + O_2$

$\underset{(Y)}{2Mg(NO_3)_2} \xrightarrow{\Delta} 2MgO + 4NO_2 + O_2$

9. **(c) :** $[Ag^+][Cl^-] = K_{sp}$ = constant

$\Rightarrow$ xy = constant

So, shape of graph should be rectangular hyperbola.

10. **(b)**

11. **(b) :** $2B + N_2 \longrightarrow \underset{\text{Boron nitride}}{2BN}$

$BN + 3H_2O \longrightarrow \underset{\substack{\text{Boric}\\\text{acid}}}{H_3BO_3} + \underset{\substack{\text{Pungent smelling}\\\text{gas}}}{NH_3}$

12. **(c) :** $H_2O_2 + Cl_2 \longrightarrow 2HCl + O_2$

As HCl (a strong acid) is produced, hence $[H^+]$ of the solution increases, pH of the solution decreases.

13. **(a) :** In most of the electrophilic aromatic substitution, 1st step is slow and second is fast. Since 1st step does not involve deprotonation, hence kinetic isotopic effect (phenomenon associated with isotopically substituted molecules exhibiting different reaction rates) is not observed in it. Hence, C_6H_6 and C_6D_6 react with almost same rate.

14. **(c) :** $\overset{+3}{Mn_2O_3} \xleftarrow{+4e^-} [\overset{+7}{KMnO_4}] \xrightarrow{+e^-} [\overset{+6}{MnO_4}]^{2-}$

$[KMnO_4] \xrightarrow{+5e^-} Mn^{2+}$; $[KMnO_4] \xrightarrow{+3e^-} \overset{+4}{MnO_2}$

15. **(c) :** Due to *ortho* effect, —CH_3 group in '3' increases acid strength and in '4' decreases basic strength.

◈◈

"Marks may be important but they don't define you," says 2009 Class 10 topper Parnail Singh

The 2008-2009 batch was the last batch of students to write the compulsory class 10 CBSE board exams in which they were awarded absolute numbers (marks). Nine years ago, a phone call from Parnail's school's principal informed her that she was the all India topper of the CBSE class 10 board examinations. She was to have been the last. The following year, Comprehensive and Continuous Evaluation (CCE) was implemented and Class X board exams were made optional. The outcomes were given in grades instead of marks. They made a comeback in 2017, which meant 2018 was the first time in nine years that class 10 board exams were held.

Parnail, whose parents are from Kanpur in Uttar Pradesh, was a student of Kendriya Vidyalaya Number 1 in Visakhapatnam, Andhra Pradesh, when she scored 494 out of 500 in the class 10 board exams. Fast forward to 2018, and Parnail lives in Gurgaon. She has just quit her job to join the prestigious Indian Institute of Management, Calcutta (IIM, Calcutta) where she will be part of the batch admitted in 2018. For the past two years, she has worked at a multinational financial services company.

Following her success in Class 10, Parnail and her family moved to Hyderabad where she enrolled in a private coaching centre to prepare for the entrance examination for admission to the Indian Institutes of Technology (IITs). After completing class 12 from Hyderabad, Parnail appeared for the Joint Entrance Examination and scored an all India rank of 1500. "I took admission at IIT, Delhi to pursue chemical engineering," she said. In some ways, hers is the all Indian dream -- topper in Class X, IIT, IIM. Both the IIT and the IIM entrance examinations are among the toughest in the world and admission rates to these schools are among the lowest, an indication of how difficult it is to get into these schools. Once in IIT, Parnail forgot all about her class 10 marks. "The board exams marks do not matter once you start a new course or a job. They do help you by giving you a head start but no one ever said to me that (because) I got good scores in class 10, I could have some leeway. I had to work as hard as everyone else," she said. Her class 10 score is not something she remembered a lot after school, but Parnail said that it did give her confidence during the moments she doubted herself. "Every time I doubted myself, I looked back at my board results and thought if I could do that then I could do other things too," she said. Parnail said students should try to be consistent from class 10 onwards because it helps while applying for higher studies. "Recently I gave CAT (Common Admission Test for admission to IIMs) and they did look at my board scores along with other things," she said.

Parnail has a message for all the students who have appeared for the compulsory class 10 board exams after years of studying under the CCE, "The syllabus is the same so doesn't matter if results are announced in grades or marks. But it is good to have some competitive spirit and class 10 boards give you that at the right time."

Still, she added: "Class 10 marks are important but they don't define you. You have to work hard to prove yourself at every stage in life." Parnail has clearly done that.

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BRUSH UP YOUR CONCEPTS

Class XI

This specially designed column will help you to brush up your concepts by practicing questions. You can mail us your queries and doubts related to this topic at editor@mtg.com. The queries will be entertained by the author.

SOME BASIC CONCEPTS OF CHEMISTRY

- Drastic changes came in the basic chemistry with the revolutionary works of scientists Perrin, Lavoisier, Loschmidt, Berzelius, Avogadro, Faraday, etc.
- Chemical symbols of elements that we use were given by Berzelius.
- Avogadro gave the term molecules for Dalton's compound atoms. According to Avogadro, an atom is the smallest particle of an element that can take part in a chemical reaction and may or may not exist free in nature. If it exists freely in nature, it is a molecule also. Molecule is the smallest particle of a pure substance that exists freely in nature. H, N, O, Cl, etc., are atoms while H_2, N_2, O_2, Cl_2, He, Ne, H_2O, CO_2, $C_{12}H_{22}O_{11}$, etc. are molecules.
- According to IUPAC (1961), atomic and molecular masses mean how much heavier is an atom or a molecule as compared to $(1/12)^{th}$ of mass of one ^{12}C atom. This reference mass is termed as unified mass (*u*) or atomic mass unit (amu) or carbon unit (cu) or avogram or dalton or aston and in grams, it is equal to 1.6605×10^{-24} grams.
- Average atomic mass is the average mass of all naturally occurring isotopes of an element.
- Collection of 6.022×10^{23} particles is termed as one mole and represents molar mass in grams (g-atom, g-molecule, g-ion, etc), molar volume of a gas [(i) 22.711 L at 0°C and 1 bar, (ii) 22.414 L at 0°C and 1 atm]

MULTIPLE CHOICE QUESTIONS

1. The mass of one atom of ^{12}C is
(a) 1.2×10^{-23} g (b) 1.66×10^{-24} g
(c) 1.99×10^{-23} g (d) 1.99×10^{-24} g

2. Boron occurs as ^{10}B and ^{11}B in nature. Average atomic mass of boron is 10.804 u. The natural abundance of ^{11}B isotope is
(a) 19.6% (b) 80.4%
(c) 26.7% (d) 89.2%

3. Chlorine occurs in nature as ^{35}Cl (75.53%) and ^{37}Cl (24.47%). The average atomic mass of chlorine is
(a) 35.49 (b) 37.24
(c) 27.92 (d) 73.42

4. An oxide A_xO_y has molecular weight 288 u. Atomic weights of *A* and O respectively are 12 and 16. The formula of the compound, if *A* is 50% by weight is
(a) A_3O_5 (b) A_5O_3
(c) $A_{12}O_9$ (d) A_9O_{12}

5. A crystalline sulphate has percentage composition: Na = 14.30%, S = 10.00%, H = 6.20% and O = 69.5%. The number of moles of water as water of crystallisation is
(a) 1 (b) 4
(c) 7 (d) 10

6. A compound A_2B_3 has 24.2% *B*. If atomic weight of *A* is 75, the atomic weight of *B* is
(a) 27 (b) 48
(c) 12 (d) 16

7. 45.3% water is lost from $FeSO_4 \cdot xH_2O$ on controlled heating. The value of *x* is [At. mass : Fe = 56 u, S = 32 u, O = 16 u, H = 1 u]
(a) 5 (b) 7
(c) 8 (d) 10

8. Haemoglobin contains 0.34% of Fe by mass. If one molecule of haemoglobin has 4 atoms

By **R.C. Grover**, having 45+ years of experience in teaching chemistry.

of Fe, the molar mass of haemoglobin is [At. mass of Fe = 55.84 u]

(a) 66666 g mol^{-1} (b) 67645 g mol^{-1}
(c) 68635 g mol^{-1} (d) 69453 g mol^{-1}

9. The mass per cent of K_2O in a sample of clay $Al_2O_3{\cdot}K_2O{\cdot}6SiO_2$ is
[At. mass : Al = 27 u, K = 39 u, Si = 28 u, O = 16 u]

(a) 1.54% (b) 16.91%
(c) 41.15% (d) 54.11%

10. Total number of protons in 1.1 g of CO_2 is
[At. mass : C = 12 u, O = 16 u]

(a) 6.022×10^{23} (b) 3.31×10^{24}
(c) 3.31×10^{23} (d) 1.204×10^{24}

11. The number of g-atoms of one atom is

(a) 6.022×10^{23} (b) 1.66×10^{-24}
(c) 2.37×10^{-23} (d) 6.022×10^{-24}

12. The number of molecules of a gas in 1 mL at STP [0 °C, 1 atm] is

(a) 1.66×10^{19} (b) 6.022×10^{19}
(c) 2.68×10^{19} (d) 1.66×10^{-24}

13. The total number of electrons in 4.4 g CO_2 is

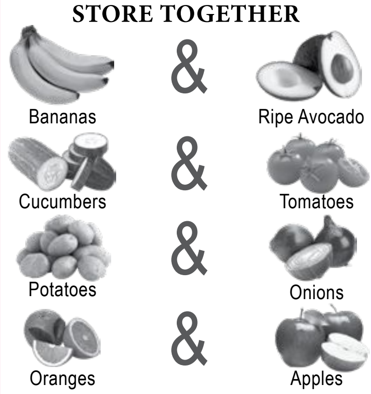
(a) $2.68 \times 10^{19} \times 3.2$
(b) $6.02 \times 10^{23} \times 2.2$
(c) $1.66 \times 10^{23} \times 4.2$
(d) $1.66 \times 10^{19} \times 2.4$

14. The number of moles of H_2SO_4 that has the same number of sulphur atoms as are present in 8 g of SO_2 is [At. mass : S = 32 u, H = 1 u, O = 16 u]

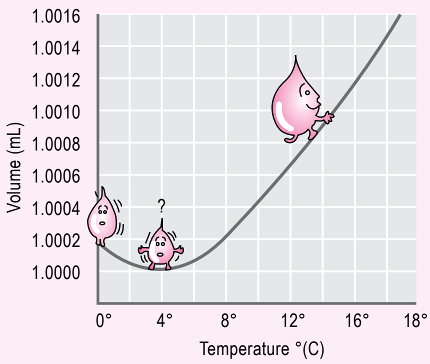
(a) 8 (b) $\frac{1}{8}$
(c) $\frac{1}{64}$ (d) $\frac{1}{98}$

3 AMAZING FACTS ABOUT CHEMISTRY

FOODS YOU SHOULD NEVER STORE TOGETHER



1. Apples and pears release ethylene gas (a natural plant hormone that sets off the ripening process) as they mature, which in turn can promote ripening in several other types of fruit. So make sure you don't store all your fruit in the same basket.



2. Above 4°C, water expands when heated and contracts when cooled. But between 4°C and 0°C, it does the opposite, contracting when heated and expanding when cooled.

When you heat ice, the molecules gain kinetic energy, and the ice expands until it melts. But once all the ice has turned to water and the temperature starts rising again, expansion stops. Between 32 and 40 degrees Fahrenheit (0 and 4 degrees Celsius), the melted water actually contracts as the temperature rises. Beyond 40 F (4° C), it starts to expand again. This phenomenon makes ice less dense than the water around it, which is the reason why ice floats.

3. Lemons contain more sugar than strawberries, for the same mass. A strawberry contains 40% sugar while a lemon has 30% more sugar content than strawberry, *i.e.* 70%. This happens because of the fact that lemon has more amount of citric acid which makes it more taste like sour than a sugary one. It has approximately 3% – 6% of acid content in it. This high amount of citric acid dominates the taste of sweetness in lemon and you savor sour taste in spite of sweet one. Rather, strawberry hardly contains any acid content.

15. 2.8861×10^{-3} moles of CO_2 are left after removing 10^{21} molecules from its x gram. The amount of CO_2 taken (x) was
(a) 50 mg (b) 100 mg
(c) 150 mg (d) 200 mg

16. One atom of an element weighs 2.65×10^{-23} g. The number of g-atoms in its 52 kg is
(a) 4142.16 (b) 5234.27
(c) 3106.42 (d) 3258.49

17. A copper coin weighing 5 g was heated with excess of conc. H_2SO_4 for complete reaction. 11.787 g of $CuSO_4{\cdot}5H_2O$ was collected. The percentage of Cu in the coin is
(a) 20% (b) 40%
(c) 60% (d) 80%

18. The volume of 100 molecules of water is ($d = 1$ g cm^{-3})
(a) 6.022×10^{-21} cm^3 (b) 3.0×10^{-21} cm^3
(c) 9.033×10^{-23} cm^3 (d) 4.5×10^{-21} cm^3

19. The mass of one mole of electrons is
(mass of one electron = 9.1×10^{-28} g)
(a) 9.1×10^{-28} g (b) 0.55 g
(c) 0.55 mg (d) 9.1×10^{-28} mg

20. Relative numbers of atoms of elements constituting a compound is $X = 2.33$, $Y = 1.25$ and $Z = 1$. The empirical formula of the compound is
(a) X_2Y_4Z (b) $X_{10}Y_5Z_4$
(c) $X_{28}Y_{15}Z_{12}$ (d) $X_{12}Y_{28}Z_{15}$

SOLUTIONS

1. **(c) :** Mass of 6.022×10^{23} atoms of ^{12}C = 12 g
Mass of one atom of ^{12}C
$$= \frac{12}{6.022 \times 10^{23}} \approx 1.99 \times 10^{-24} \text{ g}$$

2. **(b) :** Let the percentage of ^{11}B in nature be x%.
$$10.804 = \frac{(11 \times x) + 10(100 - x)}{100}$$
$\Rightarrow$ $11x + 1000 - 10x = 1080.4$
$\Rightarrow$ $x = 1080.4 - 1000 = 80.4$ %

3. **(a) :** Average atomic mass of Cl atom
$$= \frac{(37 \times 24.47) + (35 \times 75.53)}{100}$$
$$= \frac{905.39 + 2643.55}{100} \approx 35.49$$

4. **(c) :** Molar ratio $A : O = \frac{50}{12} : \frac{50}{16} = 4.16 : 3.12$
$= 1.33 : 1 = 4 : 3$
E.F. = A_4O_3
E.F.W. = $(12 \times 4) + (16 \times 3) = 96$
$$n = \frac{\text{M.F.W}}{\text{E.F.W}} = \frac{288}{96} = 3$$
Molecular formula = $(A_4O_3)_3 = A_{12}O_9$

5. **(d) :** Molar ratio, Na : S : H : O
$$= \frac{14.3}{23} : \frac{10}{32} : \frac{6.2}{1} : \frac{69.5}{16} = 0.62 : 0.31 : 6.2 : 4.34$$
= 2 : 1 : 20 : 14
The crystalline sulphate is $Na_2SO_4{\cdot}10H_2O$

6. **(d) :** Ratio of moles of A and B
$$= \frac{(100 - 24.2)}{75} : \frac{24.2}{x} = \frac{75.8}{75} : \frac{24.2}{x}$$
$$\text{For } A_2B_3, \left(\frac{75.8}{75}\right) \div \left(\frac{24.2}{x}\right) = \frac{2}{3}$$
$$\Rightarrow \frac{75.8}{75} \times \frac{x}{24.2} = \frac{2}{3} \Rightarrow x = \frac{2}{3} \times \frac{75 \times 24.2}{75.8} = 15.96 \approx 16$$

7. **(b) :** In 100 g salt, weight of H_2O = 45.3 g
Weight of $FeSO_4$ = 100 – 45.3 = 54.7 g
Molar mass of $FeSO_4 \cdot xH_2O$
$= 56 + 32 + 64 + 18x = 152 + 18x$
54.7 g $FeSO_4$, H_2O = 45.3 g
$$152 \text{ g } FeSO_4, H_2O = \frac{45.3 \times 152}{54.7} = 125.88 \text{ g}$$
$\Rightarrow$ $18x = 125.88$
$$x = \frac{125.88}{18} = 6.99 \approx 7$$

8. **(c) :** 4 moles of atoms of Fe = 1 mole of haemoglobin
(4×55.84)g, *i.e.*, 233.36 g Fe is present in one mole of haemoglobin.
Given, 0.34 g Fe is present in 100 g haemoglobin
$$233.36 \text{ g Fe will be present in } \frac{100 \times 233.36}{0.34}$$
= 68635.29 g haemoglobin

9. **(b) :** Molar mass of $Al_2O_3{\cdot}K_2O{\cdot}6SiO_2$
$= (54 + 48) + (78 + 16) + 6(28 + 32)$
$= 102 + 94 + 360 = 556$
$$K_2O\% = \frac{94}{556} \times 100 = 16.91\%$$

10. (c) : 1 mole or 44 g CO_2 has (6 + 16) *i.e.*, 22 mol protons

44 g CO_2 has 22 × 6.022 × 10^{23} protons

$$\because \quad 1.1\,g\,CO_2 \text{ will have } \frac{22\times 6.022\times 10^{23}\times 1.1}{44} \text{ protons}$$

or 3.312 × 10^{23} protons

11. (b) : 1 mole atoms = 1 g-atom

6.022 × 10^{23} atoms = 1 g-atom

$$1\text{ atom} = \frac{1}{6.022\times 10^{23}} \text{ g-atom}$$

= 1.66 × 10^{-24} g-atom

12. (c) : 22400 mL of gas (at STP) contains = 6.022 × 10^{23} molecules

$$\because \quad 1\text{ mL of gas will contain} = \frac{6.022\times 10^{23}}{22400}$$

$$= 2.68\times 10^{19} \text{ molecules}$$

13. (b) : 1 mole CO_2, *i.e.*, 44 g CO_2 has (6 + 16), *i.e.*, 22 moles of electrons

$$\because \quad 4.4\,g\,CO_2 \text{ has } \frac{22\times 6.022\times 10^{23}\times 4.4}{44} \text{ electrons}$$

= 2.2 × 6.022 × 10^{23} electrons

14. (b) : $8\,g\,SO_2$ (molar mass 64 g per mole) $= \frac{8}{64} = \frac{1}{8}$ mole

$\frac{1}{8}$ mol SO_2 has $\frac{1}{8}$ mole S-atom

1 mol H_2SO_4 has 1 mole S-atoms

$\Rightarrow \frac{1}{8}$ mole H_2SO_4 will have $\frac{1}{8}$ mole S-atoms

15. (d) : CO_2 left = 2.8861 × 10^{-3} moles

= 2.8861 × 10^{-3} × 44 g = 126.9 mg

$$10^{21} \text{ molecules of } CO_2 = \frac{44\times 10^{21}}{6.022\times 10^{23}}\,g = 73.1\,mg$$

x = mass of CO_2 left + mass of CO_2 removed

= 126.9 + 73.1 = 200 mg

16. (d) : 2.65 × 10^{-23} g = 1 atom

$$= \frac{1}{6.022\times 10^{23}} \text{ g-atoms}$$

$$52\times 10^3\,g = \frac{52\times 10^3}{2.65\times 10^{-23}\times 6.022\times 10^{23}} \text{ g-atoms}$$

$$= \frac{52\times 1000}{2.65\times 6.022} \text{ g-atoms} = 3258.49 \text{ g-atoms}$$

17. (c) : Molar mass of $CuSO_4.5H_2O$

= 63.5 + 32 + 64 + 90 = 249.5 g

Cu in 249.5 g $CuSO_4{\cdot}5H_2O$ = 63.5 g

Cu in 11.787 g $CuSO_4{\cdot}5H_2O$

$$= \frac{63.5\times 11.787}{249.5} \approx 3\,g$$

$$\text{Percentage of Cu in coin} = \frac{3}{5}\times 100 = 60\%$$

18. (b) : 6.023 × 10^{23} molecules of H_2O = 18 g

= 18 cm^3

100 molecules of H_2O

$$= \frac{18\times 100}{6.022\times 10^{23}}\,cm^3 \approx 3\times 10^{-21}\,cm^3$$

19. (c) : Mass of 1 electron = 9.1 × 10^{-28} g

Mass of 6.022 × 10^{23} electrons

= 9.1 × 10^{-28} × 6.022 × 10^{23} g

= 54.8 × 10^{-5} g = 0.548 mg ≈ 0.55 mg

20. (c) : $X : Y : Z$ = 2.33 : 1.25 : 1

= 27.96 : 15.0 : 12 (multipling by 12)

Formula = $X_{28}\,Y_{15}\,Z_{12}$

PUZZLE CORNER

SOLUTION - JUNE 2018

5	6	3	4	1	2
6	1	4	5	2	3
4	5	2	3	6	1
3	4	1	2	5	6
2	3	6	1	4	5
1	2	5	6	3	4

(a) Nitrogen (5 + 6 + 3 = 14)
(b) Calcium (4 × 5 × 2 × 1 = 40)
(c) Oxygen (6 + 4 + 5 + 1 = 16)
(d) Neodymium (4 × 2 × 3 × 6 = 144)
(e) Helium (3 + 1 = 4)
(f) Hydrogen (3 – 2 = 1)
(g) Carbon (4 × 1 × 3 = 12)
(h) Samarium (5 × 6 × 5 = 150)
(i) Boron (1 + 6 + 4 = 11)
(j) Lithium (2 + 5 = 7)

Solution Senders of Chemistry Musing

Set - 59

- Sunitha K. Reddy, Andhra Pradesh
- Devjit Acharjee, West Bengal

Solution Senders of Chemdoku

- Garima Jain, New Delhi
- Anand Parikh, Gujarat

CLASS XI

CBSE DRILL

Chapterwise practice questions for CBSE Exams as per the latest pattern and marking scheme issued by CBSE for the academic session 2018-19.

GENERAL INSTRUCTIONS

(i) All questions are compulsory.

(ii) Q. no. 1 to 5 are very short answer questions and carry 1 mark each.

(iii) Q. no. 6 to 12 are short answer questions and carry 2 marks each.

(iv) Q. no. 13 to 24 are also short answer questions and carry 3 marks each.

(v) Q. no. 25 to 27 are long answer questions and carry 5 marks each.

(vi) Use log tables if necessary, use of calculator is not allowed.

Time Allowed : 3 hours | Maximum Marks : 70

Some Basic Concepts of Chemistry | Structure of Atom

1. How are 0.50 mol Na_2CO_3 and 0.50 M Na_2CO_3 different?

2. What type of spectrum is obtained when light emitted from discharge tube containing hydrogen gas is analysed?

3. Will the molarity of a solution at 50 °C be same, less or more than molarity at 25 °C? Give reason.

4. Which of the following has shortest de-Broglie wavelength ?
O_2, H_2, a proton or an electron

5. If 20 g of sugar ($C_{12}H_{22}O_{11}$) is dissolved in enough water and the volume of the solution is adjusted to 2 L, then what is the concentration of sugar in mol L^{-1}?

6. 6×10^{24} atoms of an element weigh 200 g. If this element forms homodiatomic gas, then calculate the molar mass of the gas.

7. What are the two longest wavelength lines (in nanometers) in the Lyman series of hydrogen spectrum?

8. Calculate the number of moles of water in 488 g $BaCl_2 \cdot 2H_2O$.

9. Calculate the amount of MgS formed when 2 g Mg reacts with 2 g S.

OR

In which case the amount of carbon dioxide produced will be more?

(a) 1 mol of carbon is burnt in 16 g of dioxygen, or

(b) 2 mol of carbon is burnt in 16 g of dioxygen.

10. Arrange the electrons represented by the following sets of quantum numbers in decreasing order of energy.

(i) $n = 4,\ l = 0,\ m_l = 0,\ m_s = +1/2$

(ii) $n = 3,\ l = 1,\ m_l = 1,\ m_s = -1/2$

(iii) $n = 3,\ l = 2,\ m_l = 0,\ m_s = +1/2$

(iv) $n = 3,\ l = 0,\ m_l = 0,\ m_s = -1/2$

11. Give the name and atomic number of the inert gas in which the total number of *d*-electrons is equal to the difference between the numbers of total *p*- and total *s*-electrons.

12. Which orbit in He^+ is at the same energy level as the first orbit in the H-atom?

13. Answer the following questions :
   (i) What is the lowest shell which has f-subshell?
   (ii) Nickel atom can lose two electrons to form Ni^{2+} ion. The atomic number of nickel is 28. From which orbital will nickel lose two electrons?
   (iii) Which of the following orbitals are degenerate?
   $3s, 3p_x, 3d_{xy}, 4d_{xy}, 3d_{z^2}, 3d_{yz}, 4d_{yz}, 4d_{z^2}$

14. What is the wavelength for the electron accelerated by 1.0×10^4 volts?

15. The density of the water at room temperature is 1.0 g/mL. How many molecules are there in a drop of water if its volume is 0.05 mL?

16. An organic compound has the composition: C = 58.5%, H = 4.06%, N = 11.4% and O = 26.0%. What is the empirical formula of the compound?

17. Which among the following pairs of orbitals will experience greater effective nuclear charge?
   (i) $2s$ and $3s$ (ii) $4d$ and $4f$ (iii) $3d$ and $3p$

OR

The electron energy of hydrogen atom in the ground state is -2.18×10^{-18} J per atom. Calculate what will happen to the position of the electron in this atom if an energy of 1.938×10^{-18} J is supplied to each hydrogen atom.

18. Answer the following questions :
   (i) Give an example of a molecule in which the ratio of the molecular formula is six times the empirical formula.
   (ii) What is the molecular mass of a substance each molecule of which contains 9 atoms of carbon, 13 atoms of hydrogen and 2.33×10^{-23} g other component?

19. 1.0 g of magnesium is burnt in a closed container which contains 0.6 g of oxygen. Then, answer the following :
   (a) Which reactant is left in excess?
   (b) Find the mass of the excess reactant.

20. With what velocity must an electron travel so that its momentum is equal to that of a photon of wavelength = 5200 Å?

21. (i) Which of the following has maximum number of significant figures?
   (a) 0.00568 (b) 5.9089 (c) 6.426

   (ii) What is the mass (in grams) of an aluminium block whose dimensions are 2.0 inch × 3.0 inch × 4.0 inch and whose density is 2.7 g/cm^3? (Given : 1 inch = 2.54 cm)

22. Which of the following sets of quantum numbers is not possible? Give reasons for your answer.
   (a) $n = 0, l = 0, m_l = 0, m_s = +\frac{1}{2}$
   (b) $n = 1, l = 0, m_l = 0, m_s = -\frac{1}{2}$
   (c) $n = 1, l = 1, m_l = 0, m_s = +\frac{1}{2}$
   (d) $n = 3, l = 2, m_l = 0, m_s = -\frac{1}{2}$
   (e) $n = 3, l = 2, m_l = 3, m_s = +\frac{1}{2}$
   (f) $n = 2, l = 1, m_l = 0, m_s = +\frac{1}{2}$

23. Calcium carbonate reacts with aqueous HCl according to the reaction :
   $$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$
   What mass of $CaCO_3$ is required to react completely with 25 mL of 0.75 M HCl?

24. Answer the following questions :
   (i) How many electrons are present in NO_3^- ion ?
   (ii) An atom of an element contains 24 electrons and 28 neutrons, deduce
      (a) number of protons
      (b) electronic configuration of the element.

25. Discuss the possibility of an atom to exist in the following electronic configuration :
   (i) $1s^2\,2s^2\,2p_x^1$ (ii) $1s^2\,2s^1 2p_x^1\,2p_y^1\,2p_z^1$
   (iii) $1s^2\,2s^2\,2p_x^2\,2p_y^1$ (iv) $1s^2\,2s^2\,3s^2$
   (v) [Ar] $\overset{4s}{\boxed{\uparrow\uparrow}}$

OR

Answer the following :
   (i) In Millikan's experiment, the charge on the oil droplet was found to be -1.282×10^{-18} C. Calculate the number of electrons present in it.
   (ii) An ion with mass number 56 contains 3 units of positive charge and 30.4% more neutrons than electrons. Assign symbol to the ion.

26. The explosive trinitrotoluene (TNT), decomposes as:
   $$C_6H_2(NO_2)_3CH_{3(s)} \rightarrow 6CO_{(g)} + 5/2H_{2(g)} + 3/2N_{2(g)} + C_{(s)}$$

On explosion, what mass of TNT will form 10.0 L of gas at STP? What will be the composition of the gas produced?

OR

A mixture of oxalic acid and formic acid is heated with concentrated H_2SO_4. The gas evolved is collected and on treatment with KOH solution, the volume of solution decreases by 1/6th. Calculate the molar ratios of two acids in the original mixture.

27. Answer the following questions :

(i) If uncertainty in position of a ball of mass 1 kg is of the order of 1 Å, calculate the uncertainty in its velocity.

(ii) The electron energy in hydrogen atom is given by $E = \dfrac{-21.7\times10^{-12}}{n^2}$ ergs. Calculate the energy required to remove an electron completely from $n = 2$ orbit. What is the longest wavelength (in cm) of light that can be used to cause this transmission?

OR

Consider the electronic configurations :

(i) $1s^2 2s^1$ and (ii) $1s^2 3s^1$

(a) Name the element corresponding to (i).

(b) Does (ii) correspond to the same or different element?

(c) How can (ii) be obtained from (i)?

(d) Is it easier to remove one electron from (ii) or (i)? Explain.

SOLUTIONS

1. 0.50 mol refers to the number of moles of Na_2CO_3, which is equal to $\dfrac{\text{weight}}{\text{mol. wt.}}$.

Whereas, 0.50 M refers to the molarity of Na_2CO_3 solution which is the number of moles of solute dissolved per litre of solution.

2. Emission line spectrum.

3. Volume increases as the temperature increases and molarity is inversely proportional to volume. Hence, molarity at 50 °C will be less than molarity at 25 °C.

4. According to the de Broglie equation, $\lambda = \dfrac{h}{m\times v}$

For the same value of velocity, $\lambda \propto \dfrac{1}{m}$

$\therefore$ O_2 molecule has shortest wavelength.

5. 20 g of sugar $= \dfrac{20\text{ g}}{342\text{ g/mol}} = 0.0584795$ mol ≈ 0.06 mol

$\therefore$ Concentration $= \dfrac{0.06\text{ mol}}{2\text{ L}} = 0.03$ mol L^{-1}

6. Because gas is homodiatomic so, mol. mass $= 2 \times$ at. mass

and atomic mass = mass of 6.023×10^{23} atoms

or atomic mass $= \dfrac{200}{6\times10^{24}}\times6.023\times10^{23} \approx 20$

$\therefore$ Mol. mass $= 2 \times 20 = 40$ g mol^{-1}

7. According to Rydberg formula, $\dfrac{1}{\lambda} = R\left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right]Z^2$

As for Lyman series, $n = 1$

$\therefore$ $\dfrac{1}{\lambda} = R\left[\dfrac{1}{1^2} - \dfrac{1}{n_2^2}\right]$ ($\because Z = 1$ for hydrogen atom)

The wavelength (λ) will be longest when n_2 is the smallest *i.e.*, $n_2 = 2$ and 3

For $n = 2$; $\dfrac{1}{\lambda} = 1.097 \times 10^{-2}$ nm^{-1} $\left[\dfrac{1}{1^2} - \dfrac{1}{2^2}\right]$

$= 1.097 \times 10^{-2}$ nm$^{-1} \times \dfrac{3}{4} = 8.228 \times 10^{-3}$ nm^{-1}

$\therefore$ $\lambda = 121.54$ nm

For $n_2 = 3$; $\dfrac{1}{\lambda} = 1.097 \times 10^{-2}$ nm^{-1} $\left[\dfrac{1}{1^2} - \dfrac{1}{3^2}\right]$

$= 1.097 \times 10^{-2}$ nm$^{-1} \times \dfrac{8}{9} = 9.75 \times 10^{-3}$ nm^{-1}

$\therefore$ $\lambda = 102.56$ nm

8. Mol. wt. of $BaCl_2 . 2H_2O = 244$ g

244 g $BaCl_2\cdot 2H_2O$ has 36 g of water or 2 moles of water

$\therefore$ 488 g will have $= \dfrac{2\times488}{244} = 4$ moles of H_2O

9.
$$\underset{\substack{1\text{ mole}\\24\text{ g}}}{Mg} + \underset{\substack{1\text{ mole}\\32\text{ g}}}{S} \longrightarrow MgS$$

Thus, when 2 g S (*i.e.*, 2/32 mole) reacts with Mg, S acts as limiting reagent while Mg is in excess. Thus, amount of product will be decided by moles of S not by moles of Mg, therefore

1 mole S ≡ 1 mole MgS

$\therefore$ Moles of MgS formed $= \dfrac{2}{32}$

and mass of MgS formed = $\frac{2}{32} \times 56 = 3.5$ g

OR

The combustion reaction of carbon is $C + O_2 \rightarrow CO_2$.
1 mol of C produces 1 mol of CO_2.

(a) 16 g of O_2 = 16 g of $O_2 \times \frac{1\text{ mol } O_2}{32\text{ g } O_2} = 0.5$ mol O_2

0.5 mol of O_2 requires 0.5 mol of C. C is in excess, so O_2 is the limiting reactant. 0.5 mol of O_2 will give 0.5 mol of CO_2.

(b) 16 g O_2 (= 0.5 mol) requires 0.5 mol of C. C is in excess. O_2 is the limiting reactant. The amount of CO_2 produced will be 0.5 mol.

Hence, in both the cases, same amount of CO_2 will be produced.

10. Find $(n + l)$ for each set

(i) $(n + l) = 4$ *i.e.,* $4s$ **(ii)** $(n + l) = 4$ *i.e.,* $3p$

(iii) $(n + l) = 5$ *i.e.,* $3d$ **(iv)** $(n + l) = 3$ *i.e.,* $3s$

$\therefore$ Decreasing order of energy is (iii) > (i) > (ii) > (iv)

11. Electronic configuration of Kr (atomic no. = 36) : $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6$

Total no. of s-electrons = 8

Total no. of p-electrons = 18

Difference between no. of s- and p-electrons = 18 – 8 = 10, which is equal to no. of d-electrons.

12. From the expression for the energy of an electron in the n^{th} orbit, it is clear that the energy of the orbits is proportional to Z^2/n^2. Orbits in two different atoms are at the same energy level if the value of Z^2/n^2 is the same for both.

$\frac{Z^2}{n^2} = 1$ for the first orbit in the H atom.

For He^+, $\frac{Z^2}{n^2} = 1$, if $n = 2$ $\quad (\because Z = 2 \text{ for He})$

Hence, the second orbit in He^+ and the first in the H-atom are at the same energy level.

13. **(i)** For f-subshell, $l = 3$

For a value of n, possible values of l are 0 to n – 1.

$l = n - 1 \Rightarrow n = l + 1 = 3 + 1 = 4$

Thus, the lowest value of n that allows f-subshell to exist is 4.

(ii) $Ni(Z = 28) : 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^8\, 4s^2$

$Ni^{2+} : 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^8$

Hence, two electrons are lost from $4s$-orbital.

(iii) $3d_{xy}$, $3d_{z^2}$, $3d_{yz}$ and $4d_{xy}$, $4d_{yz}$, $4d_{z^2}$ are the sets of degenerate orbitals.

14. Energy (kinetic energy) of electron = 1.0×10^4 volts

$= 1.0 \times 10^4 \times 1.6 \times 10^{-19}$ J $= 1.6 \times 10^{-15}$ J

$= 1.6 \times 10^{-15}$ kg m^2 s^{-2}

or $1/2\, mv^2 = 1.6 \times 10^{-15}$ kg m^2 s^{-2}

or $v = \left(\frac{2 \times 1.6 \times 10^{-15}\text{ kg m}^2\text{s}^{-2}}{9.1 \times 10^{-31}\text{ kg}}\right)^{1/2} = 5.93 \times 10^7$ m s^{-1}

According to de Broglie equation,

$$\lambda = \frac{h}{mv};\ \lambda = \frac{(6.626 \times 10^{-34}\text{ kg m}^2\text{s}^{-1})}{(9.1 \times 10^{-31}\text{ kg}) \times (5.93 \times 10^7\text{ ms}^{-1})}$$

$= 1.22 \times 10^{-11}$ m

15. Volume of a drop of water = 0.05 mL

Mass of a drop of water = volume × density

= (0.05 mL) × (1.0 g/mL)

= 0.05 g

Gram molecular mass of water (H_2O)

$= 2 \times 1 + 16 = 18$ g

18 g of water contains = 1 mol

$\therefore$ 0.05 g of water contains = $\frac{1\text{ mol}}{18\text{ g}} \times 0.05$ g

= 0.0028 mol

$\because$ 1 mole of water contains = 6.022×10^{23} molecules

0.0028 mole of water will contain = $6.022 \times 10^{23} \times 0.0028$

$= 1.68 \times 10^{21}$ molecules

16.

Element	% Composition	Relative no. of atoms = Percentage / Atomic mass	Simplest ratio
C	58.5	58.5/12.0 = 4.88	4.88/0.814 = 5.99 ≈ 6
H	4.06	4.06/1.01 = 4.02	4.02/0.814 = 4.94 ≈ 5
N	11.4	11.4/14.0 = 0.814	0.814/0.814 = 1.00
O	26.0	26.0/16.0 = 1.63	1.63/0.814 = 2.002 ≈ 2

Thus, the empirical formula of the compound is $C_6H_5NO_2$.

17. The more penetrating orbital experiences greater effective nuclear charge.

(i) $2s$ is more penetrating than $3s$ because of its lower principal quantum number. Hence, $2s$ experiences greater effective nuclear charge.

(ii) Among orbitals of the same shell, those with lower azimuthal quantum number are more penetrating thus, 4*d* experiences greater effective nuclear charge.
(iii) 3*p* experiences greater effective nuclear charge.

OR

Energy of electron in the ground state of H atom

$= -2.18 \times 10^{-18}$ J atom^{-1}

Energy supplied $= 1.938 \times 10^{-18}$ J atom^{-1}

$\therefore$ Total energy of electron $= -2.18 \times 10^{-18} + 1.938 \times 10^{-18}$

$= -0.242 \times 10^{-18}$ J atom^{-1}

Energy of electron in n^{th} shell for H-atom

$$= -\frac{2.18 \times 10^{-18}}{n^2} \text{ J atom}^{-1}$$

$$\therefore \frac{-2.18 \times 10^{-18}}{n^2} = -0.242 \times 10^{-18} \quad \text{or} \quad n^2 = 9$$

$\therefore n = 3$

Hence, electron will go to $n = 3$ shell.

18. (i) The compound is glucose. Its molecular formula is $C_6H_{12}O_6$, while empirical formula is CH_2O.
(ii) Mass of 9 atoms of carbon = 9 × 12 amu = 108 u
Mass of 13 atoms of hydrogen = 13 × 1 amu = 13 u
Mass of 2.33×10^{-23} g of other component

$$= (1\text{ u}) \times \frac{(2.33 \times 10^{-23}\text{ g})}{(1.66 \times 10^{-24}\text{ g})} = 14.04\text{ u}$$

Molecular mass of the substance = (108 + 13 + 14.04) u
= 135.04 u

19. The reaction is:

$$\underset{\substack{2 \times 24\text{ g} \\ = 48\text{ g} \\ 1\text{ g}}}{2Mg} + \underset{\substack{2 \times 16\text{ g} \\ = 32\text{ g} \\ \frac{32}{48} \times 1 = 0.667\text{ g}}}{O_2} \rightarrow \underset{\substack{2 \times (24+16)\text{g} \\ = 80\text{ g}}}{2MgO}$$

(a) Thus, 1 g of magnesium would require 0.667 g of oxygen for complete combustion. In the container, only 0.6 g of oxygen is available. Therefore, a part of magnesium is left unreacted.
(b) From the reaction stoichiometry,
32 g of oxygen will react with 48 g of Mg

0.6 g of oxygen will react with $\frac{48}{32} \times 0.6 = 0.9$ g of Mg

Therefore, mass of magnesium left behind
= 1.0 – 0.9 = 0.1 g

20. According to de Broglie equation, $\lambda = \frac{h}{mv}$

$$\therefore \quad mv = \frac{h}{\lambda} = \frac{(6.626 \times 10^{-34}\text{ kg m}^2\text{ s}^{-1})}{(5200 \times 10^{-10}\text{ m})}$$

$$= 1.274 \times 10^{-27}\text{ kg m s}^{-1} \quad ...(i)$$

Momentum of electron can also be calculated as,

$$mv = (9.1 \times 10^{-31}\text{ kg}) \times v \quad ...(ii)$$

Comparing equations (*i*) and (*ii*),

$$(9.1 \times 10^{-31}\text{ kg}) \times v = (1.274 \times 10^{-27}\text{ kg m s}^{-1})$$

$$v = \frac{(1.274 \times 10^{-27}\text{ kg m s}^{-1})}{(9.1 \times 10^{-31}\text{ kg})} = 1.4 \times 10^3\text{ m s}^{-1}$$

21. (i) (a) 3 **(b)** 5 **(c)** 4
Thus, (b) has maximum number of significant figures.
(ii) Here, unit conversion factors are 1 inch = 2.54 cm

$$\frac{2{\cdot}54\text{ cm}}{1\text{ inch}} = 1 = \frac{1\text{ inch}}{2{\cdot}54\text{ cm}}$$

Hence, required mass (in g) = 2·0 inch × 3·0 inch × 4·0 inch

$$\times \frac{2{\cdot}54\text{ cm}}{1\text{ inch}} \times \frac{2{\cdot}54\text{ cm}}{1\text{ inch}} \times \frac{2{\cdot}54\text{ cm}}{1\text{ inch}} \times \frac{2{\cdot}7\text{ g}}{1\text{ cm}^3}$$

$= 1.06 \times 10^3$ g

22. (a) Not possible, because *n* can never be zero.
(b) 1*s*-orbital
(c) Not possible, because the maximum possible value of *l* is $n - 1 = 1 - 1 = 0$.
(d) 3*d*-orbital
(e) Not possible, because for a particular value of *l*, value of $m = -l$ to $+l$.
(f) 2*p*-orbital

23. 1000 mL of 0.75 M HCl contain = 0.75 mol
= 0.75 × 36.5 g = 27.375 g HCl

$\therefore$ 25 mL of 0.75 HCl will contain $= \frac{27.375}{1000} \times 25$ g

= 0.6844 g HCl

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

2 mol of HCl, *i.e.*, 2 × 36.5 g = 73 g HCl reacts completely with 1 mole of $CaCO_3$ (= 100 g)

$\therefore$ 0.6844 g HCl will react completely with $CaCO_3$

$$= \frac{100}{73} \times 0.6844\text{ g} = 0.938\text{ g}$$

24. (i) NO_3^- ion has 7 + 8 × 3 + 1 = 7 + 24 + 1
= 32 electrons.

MONTHLY TUNE UP CLASS XI ANSWER KEY

1. (b)	2. (d)	3. (c)	4. (c)	5. (b)
6. (b)	7. (a)	8. (c)	9. (b)	10. (c)
11. (a)	12. (c)	13. (c)	14. (b)	15. (d)
16. (d)	17. (a)	18. (a)	19. (a)	20. (a,c)
21. (b,c)	22. (b,c)	23. (b,d)	24. (0.875)	
25. (2)	26. (1.028)	27. (c)	28. (d)	29. (d)
30. (a)				

(ii) (a) For a neutral element, no. of protons = no. of electrons = 24

(b) Atomic number of element = no. of protons = 24

Electronic configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^5$

25. (i) This electronic configuration is correct since it is in accordance with the rules for filling up various orbitals.

(ii) This electronic configuration is wrong because it violates Aufbau principle which states that an orbital with lower energy, *i.e.*, $2s$, in the present case should be completely filled before the electrons go to higher energy subshell, *i.e.*, $2p$. Thus, the correct electronic configuration will be $1s^2\,2s^2\,2p_x^1\,2p_y^1$.

(iii) This electronic configuration is not correct since it violates Hund's rule. According to this rule, all the three $2p$ orbitals must have one electron each before the pairing occurs. But in the present case $2p_x$ orbital has two electrons while $2p_z$ orbital is empty. Thus, the correct electronic configuration will be $1s^2\,2s^2\,2p_x^1\,2p_y^1\,2p_z^1$.

(iv) This electronic configuration is wrong since after filling $2s$-orbital, the electrons should go to $2p$-orbitals rather than $3s$-orbital. Thus, the correct electronic configuration will be $1s^2\,2s^2\,2p^2$.

(v) This is violating Pauli's exclusion principle as both electrons in the given configuration have same spins. Thus, the correct electronic configuration will be $[Ar]\overset{4s}{\boxed{\uparrow\downarrow}}$.

OR

(i) Charge on oil droplet = -1.282×10^{-18} C

Charge on an electron = -1.602×10^{-19} C

$$\text{Number of electrons} = \frac{q}{q_e} = \frac{(-1.282\times10^{-18}\,\text{C})}{(-1.602\times10^{-19}\,\text{C})} = 8$$

(ii) Let the no. of electrons in the ion be x.

$\therefore$ The no. of protons = $x + 3$

(as the ion has three units of positive charge)

And the no. of neutrons = $x + \frac{30.4x}{100} = x + 0.304\,x$

Now, mass number of ion = No. of protons + No. of neutrons

$= (x + 3) + (x + 0.304\,x)$

$\therefore$ $56 = (x + 3) + (x + 0.304\,x)$ or $2.304\,x = 56 - 3 = 53$

$$x = \frac{53}{2.304} = 23$$

Atomic no. of the ion (or element) = 23 + 3 = 26

The element with atomic number 26 is iron (Fe) and the corresponding ion is Fe^{3+}.

26. 10 mol of gas is produced from 1 mol of TNT.

Volume occupied by 10 mol of gas at STP

= 10 mol × 22.4 L/mol = 224 L

Now, 224 L of gas (at STP) is produced by 1 mol of TNT.

$\therefore$ 10.0 L of gas is produced by $= 10.0\text{ L} \times \frac{1\text{ mol}}{224\text{ L}}$

$= 4.46 \times 10^{-2}$ mol of TNT

$\therefore$ The mass of TNT required $= 4.46 \times 10^{-2}$ mol $\times 227\text{ g mol}^{-1} = 10.12$ g

The total volume of gas produced will contain the different proportion of gases to their corresponding stoichiometric coefficients. Hence, in the total volume of gas, CO, H_2 and N_2 will be in the proportion 6 : 2.5 : 1.5

Thus, volume of CO $= 10.0\text{ L}\times\frac{6}{6+2.5+1.5} = 10.0\text{ L}\times\frac{6}{10}$

= 6.0 L,

volume of H_2 $= 10.0\text{ L}\times\frac{2.5}{6+2.5+1.5} = 10.0\text{ L}\times\frac{2.5}{10}$

= 2.5 L,

and volume of N_2 = 10.0 L – (6.0 L + 2.5 L) = 1.5 L

OR

Let x moles of oxalic acid and y moles of formic acid be heated with conc. H_2SO_4 according to the following equations :

$$\underset{x\text{ mol}}{\begin{matrix}\text{COOH}\\ |\\ \text{COOH}\end{matrix}} \xrightarrow{H_2SO_4/\text{heat}} \underset{x\text{ mol}}{CO_{(g)}} + \underset{x\text{ mol}}{CO_{2(g)}} + H_2O_{(l)}$$

$$\underset{y\text{ mol}}{\text{HCOOH}} \xrightarrow{H_2SO_4/\text{heat}} \underset{y\text{ mol}}{CO_{(g)}} + H_2O_{(l)}$$

Total moles of gaseous mixture = Moles of CO + Moles of CO_2

= $(x + y)$ mol + x mol = $(2x + y)$ mol

Now, KOH absorbs only CO_2 *i.e.*, x moles and the volume of the solution decreases by $1/6^{th}$ of its volume.

$$\therefore \frac{\text{Moles of } CO_2}{\text{Moles of both gases}} = \frac{x}{(2x+y)} = \frac{1}{6}$$

or, $6x = 2x + y$ or $4x = y$ or $y/x = 4$

$\therefore$ Molar ratio of formic acid : oxalic acid = 4 : 1

27. (i) According to Heisenberg's uncertainty principle,

$$\Delta x \times \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x \times m\Delta v = \frac{h}{4\pi} \quad (\Delta p = m \times \Delta v)$$

$$\therefore \Delta v = \frac{h}{4\pi m\Delta x} = \frac{6.626\times10^{-34}\text{ kg m}^2\text{ s}^{-1}}{4\times3.14\times1\text{kg}\times10^{-10}\text{m}}$$

$= 5.275 \times 10^{-25}$ m s^{-1}

(ii) Applying Bohr's theory, $E_{req} = E_\infty - E_2$

Energy in 2nd orbit is $E_2 = \dfrac{-21.7\times10^{-12}}{2^2}$

$= -5.425 \times 10^{-12}$ erg and $E_\infty = 0$

$\therefore$ Energy required to remove an electron from $n = 2$ to $n = \infty$

$$\Delta E = E_{req} = 0 - (-5.425 \times 10^{-12})$$

Energy supplied $= 5.425 \times 10^{-12}$ ergs

Acc. to quantum equation, $\Delta E = \dfrac{hc}{\lambda}$

To determine wavelength,

$$\lambda = \frac{hc}{\Delta E} = \frac{6.626\times10^{-27}\times3\times10^{10}}{5.425\times10^{-12}} = 3.66 \times 10^{-5}\text{ cm}$$

OR

(a) The element corresponding to (i) is lithium (Li).

(b) This electronic configuration represents the same element in the excited state.

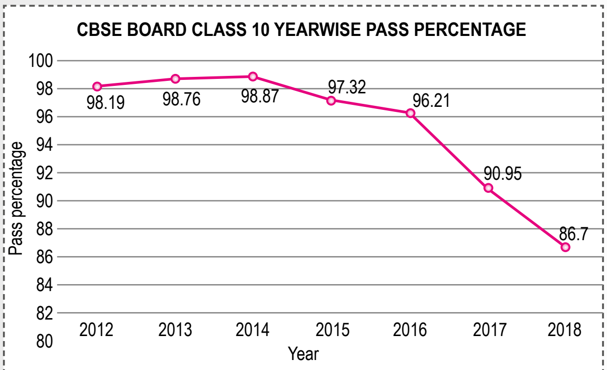
(c) By supplying energy to the element, the electron jumps from the lower energy $2s$-orbital to the higher energy $3s$-orbital.

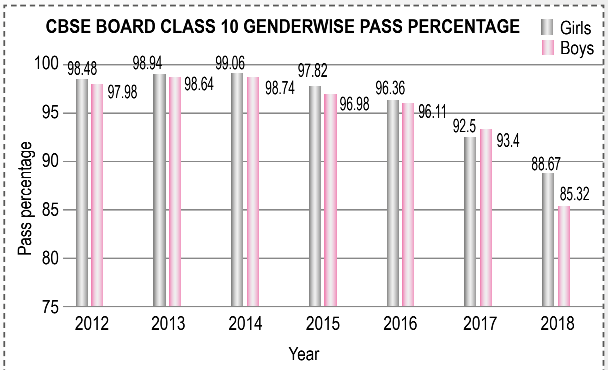
(d) It is easier to remove an electron from (ii) than from (i) since in the former case, the electron is present in a $3s$-orbital which is away from the nucleus and hence is less strongly attracted by the nucleus than an electron in the $2s$-orbital.

CBSE BOARD YEARWISE PASS PERCENTAGE

Class 10

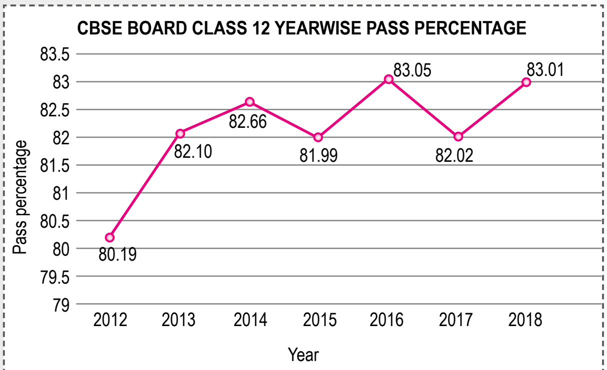
In 2009 the Ministry of Human Resource and Development (MHRD) had recommended that Class 10 Board exams be made optional. The plan was implemented in 2010-11 and a Continuous Comprehensive Evaluation (CCE) system was put in place to assess students on academics as well as their debating skills, creativity and ability to debate or make presentations. Exams were staggered through the year – as formative tests four times a year and summative tests twice a year and the scores were totalled finally. This year, the boards have been made mandatory again with a student's scores largely dependent on how he or she performs in the final exam.

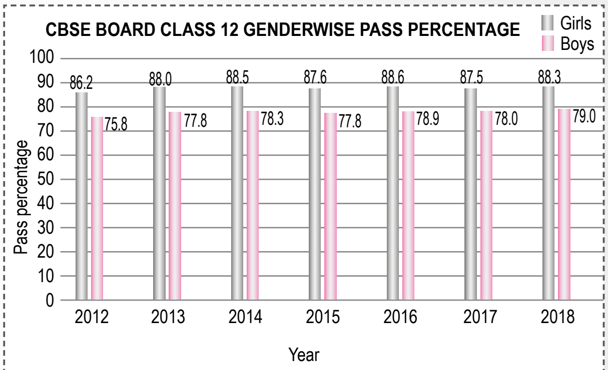




Class 12

The overall pass percentage at the national level increased from last year's 82.02 to 83.01%. CBSE officials said 12,737 students scored above 95%, 2,646 more than last year. A total of 1.18 million students sat for the exam.





(Figures in Percentage in India)

Class XI

MONTHLY TUNE UP!

PRACTICE PROBLEMS

These practice problems enable you to self analyse your extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Performance analysis table given at the end will help you to check your readiness.

- Some Basic Concepts of Chemistry

Total Marks : 120 **Time Taken : 60 Min.**

NEET / AIIMS

Only One Option Correct Type

1. What weight of $CaCO_3$ must be decomposed to produce the sufficient quantity of carbon dioxide to convert 21.2 kg of Na_2CO_3 completely into $NaHCO_3$? [Atomic mass of Na = 23, Ca = 40]
$CaCO_3 \longrightarrow CaO + CO_2$
$Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$
(a) 50 kg (b) 20 kg (c) 120 kg (d) 100 kg

2. In Haber's process, 30 litres of dihydrogen and 30 litres of dinitrogen were taken for reaction which yielded only 50% of the expected product. What will be the composition of the gaseous mixture under the aforesaid condition at the end?
(a) 20 litres NH_3, 25 litres N_2, 20 litres H_2
(b) 10 litres NH_3, 5 litres N_2, 15 litres H_2
(c) 20 litres NH_3, 10 litres N_2, 30 litres H_2
(d) 10 litres NH_3, 25 litres N_2, 15 litres H_2.

3. 3 g of Mg is burnt in a closed vessel containing 3 g of oxygen. The weight of excess reactant left is
(a) 0.5 g of oxygen (b) 1.0 g of Mg
(c) 1.0 g of oxygen (d) 0.5 g of Mg.

4. 0.7 g of iron combines directly with 0.4 g of sulphur to form ferrous sulphide. If 2.8 g of iron is dissolved in dilute HCl and excess of sodium sulphide solution is added, 4.4 g of iron sulphide is precipitated. The data illustrates
(a) Avogadro's law
(b) law of conservation of mass
(c) law of constant composition
(d) law of multiple proportion.

5. 4 g of copper was dissolved in concentrated nitric acid. The copper nitrate on strong heating gave 5 g of its oxide. The equivalent weight of copper is
(a) 23 (b) 32 (c) 12 (d) 20

6. Which of the following will have the same number of electrons as 1 g hydrogen atom?
(a) 1 g oxygen atom (b) 2 g oxygen atom
(c) 1 g carbon atom (d) 1 g nitrogen atom

7. The empirical formula of an organic compound containing carbon and hydrogen is CH_2. The mass of one litre of this organic gas is exactly equal to that of one litre of N_2. Therefore, the molecular formula of the organic gas is
(a) C_2H_4 (b) C_3H_6
(c) C_6H_{12} (d) C_4H_8

8. 5.85 g of NaCl is dissolved in 1 L of pure water. The number of ions in 1 mL of this solution is
(a) 6.02×10^{23} (b) 1.2×10^{22}
(c) 1.2×10^{20} (d) 6.02×10^{10}

9. A metal *M* with specific heat 0.16, has 63.8% chlorine, then the formula of the compound is similar to
(a) MCl (b) MCl_2 (c) MCl_3 (d) MCl_4

10. Equivalent weight of carbon in CO and CO_2 are in the ratio of
(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) 1 : 4

11. Mixture X containing 0.02 mole of $[Co(NH_3)_5SO_4]Br$ and 0.02 mol of $[Co(NH_3)_5Br]SO_4$ was prepared in 2 litre of solution.
1 litre of mixture X + excess $AgNO_3 \rightarrow Y$
1 litre of mixture X + excess of $BaCl_2 \rightarrow Z$
Number of moles of Y and Z are
(a) 0.01, 0.01 (b) 0.02, 0.01
(c) 0.01, 0.02 (d) 0.02, 0.02

12. The temperature at which molarity of pure water is equal to its molality is
(a) 273 K (b) 298 K
(c) 277 K (d) 302 K

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. Assertion : Normality of 0.3 M phosphorous acid (H_3PO_3) is 0.6 N.
Reason : It is a tribasic acid.

14. Assertion : For a solution, 92 g of ethanol and 144 g of water is mixed, mole fraction of ethanol and water in the solution is 0.2 and 0.8 respectively.
Reason : The sum of the mole fractions of all the components in a solution is unity.

15. Assertion : S.I. unit of atomic mass and molecular mass is kilograms.
Reason : Atomic mass is equal to the mass of 6.023×10^{24} atoms.

JEE MAIN / ADVANCED

Only One Option Correct Type

16. When a g of carbon is heated with b g of oxygen in a closed vessel, no solid residue is left behind. Which of the following statements is correct?
(a) b/a must be in between 1.33 and 2.67.
(b) b/a must be greater than or equal to 2.67.
(c) b/a must be less than or equal to 1.33.
(d) b/a must be greater than or equal to 1.33.

17. Rearrange the following (I to IV) in the order of increasing masses and choose the correct answer.
(I) 1 atom of oxygen
(II) 1 atom of nitrogen
(III) 1×10^{-10} g molecular mass of oxygen
(IV) 1×10^{-7} g atomic mass of copper
(a) II < I < III < IV (b) IV < III < II < I
(c) II < III < I < IV (d) III < IV < I < II.

18. A and B are two elements which form A_2B_3 and A_3B_4. If 0.20 mol of A_2B_3 weighs 32.0 g and 0.4 mol of A_3B_4 weighs 92.8 g, the atomic weights of A and B are respectively
(a) 56.0 and 16.0 (b) 8.0 and 28.0
(c) 16.0 and 56.0 (d) 28.0 and 8.0

19. Mole fraction of A in H_2O is 0.2. The molality of A in H_2O is
(a) 13.9 (b) 10.5 (c) 14.5 (d) 15.8

More than One Options Correct Type

20. $$\left(\underset{C_2H_5}{\overset{C_2H_5}{\underset{|}{\overset{|}{C}}}}H\text{—}COOH\right)_n + \underset{\text{(excess)}}{AgNO_3} \longrightarrow \text{Silver salt} \xrightarrow{} \text{Ag (metal)}$$

If 0.5 mole of silver salt is taken and weight of residue obtained is 216 g, then which of the following are correct?
(a) $n = 4$ (b) $n = 1$
(c) Mol.wt. of silver salt is 718 g/mol
(d) Mol.wt. of silver salt is 223 g/mol

21. The atomic weights of two elements A and B are 20 and 40 respectively. Which of the following statements are correct for these two elements?
(a) x g of A contains y atoms which is equal to atoms present in x g of B.
(b) x g of A contains y atoms which is equal to atoms present in $2x$ g of B.
(c) At STP, x L of monoatomic gas A is equal to x L of monoatomic gas B.
(d) At STP, x L of monoatomic gas A is equal to $2x$ L of monoatomic gas B.

22. Among the species given below which have same mass?
(a) 0.1 g-molecule of SO_2
(b) 0.1 g-molecule of N_2O
(c) 0.1 g-molecule of dry ice
(d) Avogadro number of CO molecules

23. Equal volume of 0.1M NaCl and 0.1M $FeCl_2$ are mixed with no change in volume due to mixing. Which of the following will be true for the final solution (no precipitation occurs)? Assume complete dissociation of salts and neglect any hydrolysis.
(a) $[Na^+] = 0.1$ M (b) $[Fe^{2+}] = 0.05$ M
(c) $[Cl^-] = 0.3$ M (d) $[Cl^-] = 0.15$ M

Numerical Value

24. In an iodometric estimation, the following reactions occur

$$2Cu^{2+} + 4I^{-} \longrightarrow Cu_2I_2 + I_2;$$
$$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

0.15 mol of $CuSO_4$ of 70% purity was added to excess of KI solution and the liberated iodine required 120 mL of hypo. Calculate the molarity of hypo solution.

25. A welding fuel gas contains carbon and hydrogen only. Burning a small sample of it in oxygen gives 3.88 g carbon dioxide, 0.690 g of water and no other products. A volume of 10.0 L (measured at STP) of this welding gas is found to weigh 11.6 g. If the molecular formula of the gas is $(CH)_n$ then calculate the value of n.

26. If 1 g of $H_{2(g)}$ reacts with 1 g of $Cl_{2(g)}$ in a closed container, then how many grams of HCl will be produced during the reaction?

Comprehension Type

A sample of iron (II) sulphate crystals, $FeSO_4{\cdot}7H_2O$ had been left open to the air and some of the iron (II) ions had been converted to iron (III). 4.2 g of the impure crystals were dissolved in a total of 250 cm^3 water and dilute sulphuric acid. 25 cm^3 portion of this solution was titrated with a solution of potassium dichromate (VI). The concentration of dichromate (VI) ions in this solution was 0.1 mol dm^{-3}. The average titre used was 23.5 cm^3.

27. How many moles of Fe^{2+} ions would there have been in the 250 cm^3 of stock solution?
(a) 7.05×10^{-4} mol (b) 2.35×10^{-4} mol
(c) 1.41×10^{-2} mol (d) 7.05×10^{-3} mol

28. The percentage purity of the crystal is
(a) 69% (b) 72% (c) 88% (d) 94%

Matrix Match Type

29. Match Column I with Column II and choose the correct answer using the codes given below :

	Column I		Column II
A.	Molarity	p.	Temperature
B.	Molality	q.	Pressure
C.	Mole fraction	r.	Dilution
D.	Normality	s.	Volume

Codes :

	A	B	C	D
(a)	p, q, s	p, q	q, r, s	p, q
(b)	p, r	p, q, r, s	p, q	p, q, s
(c)	q, r, s	p, q, r	q, r	q, s
(d)	p, q, r, s	q, r	q, r	p, q, r, s

30. Match Column I with Column II and choose the correct answer using the codes given below :

	Column I		Column II
A.	$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(s)} + H_{2(g)}$; reaction is carried out by taking 2 moles each of Zn and HCl	p.	50% of excess reactant is left
B.	$AgNO_{3(aq)} + HCl_{(aq)} \rightarrow AgCl_{(s)} + HNO_{3(g)}$; reaction is carried out by taking 170 g $AgNO_3$ and 18.25 g HCl	q.	22.4 L of gas at STP is liberated
C.	$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$; 100 g $CaCO_3$ is decomposed	r.	1 mole of solid (product) is obtained
D.	$2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$; 2/3 moles of $KClO_3$ is decomposed	s.	HCl is the limiting reactant

Codes :

	A	B	C	D
(a)	p, q, r, s	p, s	q, r	q
(b)	p, q, s	p, s	p, q	q
(c)	q, r	p, q, r, s	q, r	r
(d)	p, r, s	p, q	q	p, r

Keys are published in this issue. Search now! ☺

CHECK YOUR PERFORMANCE

No. of questions attempted	……
No. of questions correct	……
Marks scored in percentage	……

If your score is

> 80%	Your preparation is going good, keep it up to get high score.
60-80%	Need more practice, try hard to score more next time.
<60%	Stress more on concepts and revise thoroughly.

Class XII

FOCUS NEET/JEE 2019

Focus more to get high rank in NEET, JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

UNIT - 1 : The Solid State / Solutions

THE SOLID STATE

General Characteristics

- Solids have definite mass, volume and shape due to the fixed positions of their constituent particles.
- Solids have short intermolecular distances and strong intermolecular forces.
- The constituent particles of solid (atoms, molecules or ions) have fixed positions and can only oscillate about their mean positions.
- Solids are incompressible and rigid.

Classification

Solids

Crystalline Solids	Amorphous Solids
Ordered arrangement of particles	Irregular arrangement of particles
Long range order	Short range order
Anisotropic	Isotropic
Sharp melting point	Melt over a range of temperature

Crystal Lattice

The regular arrangement of an infinite set of points which describes the three-dimensional arrangement of constituent particles (atoms, ions or molecules) in space is called a crystal lattice or space lattice.

Unit Cell

- The smallest repeating unit of space lattice which when repeated over and over again in three-dimension, results into the whole of the space lattice of the crystal is called the unit cell.
- **Calculation of number of particles per unit cell :**
Contribution of each atom present at the corner = 1/8
Contribution of each atom present on the face = 1/2
Contribution of each atom present on the edge centre = 1/4
Contribution of each atom present at the body centre = 1

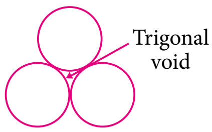
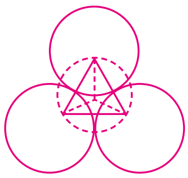
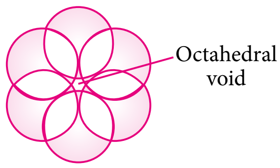
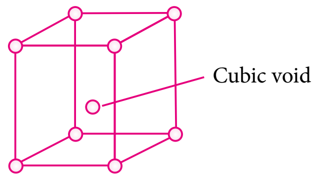
Characteristics of Different Types of Unit Cells

Characteristics	*sc*	*bcc*	*fcc*	*hcp*
Number of Atoms per unit cell	1	2	4	6
Coordination number	6	8	12	12
Packing efficiency	52%	68%	74%	74%
Radius (r)	$\frac{a}{2}$	$\frac{\sqrt{3}}{4}a$	$\frac{a}{2\sqrt{2}}$	$\frac{a}{2}$

Seven Types of Crystal Systems

Crystal systems	Axial distances or edge lengths	Axial angles	Examples
Cubic (most symmetrical)	$a = b = c$	$\alpha = \beta = \gamma = 90°$	Cu, Zinc blende, KCl, NaCl
Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	Sn(White tin), SnO_2, TiO_2, $CaSO_4$
Orthorhombic or Rhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	Rhombic sulphur, KNO_3, $BaSO_4$
Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90°; \beta \neq 90°$	Monoclinic sulphur, $Na_2SO_4 \cdot 10H_2O$
Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°; \gamma = 120°$	Graphite, ZnO, CdS
Rhombohedral or Trigonal	$a = b = c$	$\alpha = \beta = \gamma \neq 90°$	$CaCO_3$ (Calcite), HgS (Cinnabar)
Triclinic (most unsymmetrical)	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$	$K_2Cr_2O_7$, $CuSO_4 \cdot 5H_2O$, H_3BO_3

Interstitial Sites in Closed Packed Structures

Trigonal Void	Tetrahedral Void	Octahedral Void	Cubic Void
 Trigonal void is formed at the centre of three spheres	 Tetrahedral void is formed by covering trigonal voids	 Octahedral void is formed at the centre of six spheres	
$r = 0.155\ R$	$r = 0.225\ R$	$r = 0.414\ R$	$r = 0.732\ R$
where r = radius of void, R = Radius of closely packed spheres			

Calculation Involving Unit Cell Dimensions

Radius Ratio

$$\text{Radius ratio} = \frac{\text{Radius of cation}}{\text{Radius of anion}} = \frac{r_+}{r_-}$$

Packing Fraction

$$f = \frac{\text{Number of spheres/unit cell } (Z) \times \text{Volume of one spheres in the unit cell}}{\text{Volume of the unit cell } (V)} = \frac{Z \times \frac{4}{3}\pi r^3}{a^3}$$

Density

$$\rho = \frac{Z \times M}{a^3 \times N_A}$$

where, Z = no. of atoms/unit cell,

M = atomic mass of the element,

a = edge length of the unit cell,

N_A = Avogadro's number

Limiting Radius Ratio, Coordination Number and Geometry

r_+/r_-	C. No.	Geometry
< 0.155	2	Linear
0.155 - 0.225	3	Plane triangular
0.225 - 0.414	4	Tetrahedral
0.414 - 0.732	6	Octahedral
0.732 - 1.000	8	Cubic (body centred)

Defects in Solids

Imperfections/Defects in Solids

- **Point defects**
  Deviations from ideal arrangement around a point or an atom.
  - **Stoichiometric/Intrinsic/Thermodynamic defects**
    Do not disturb stoichiometry of solid.
    - **Vacancy defect :** Arises when lattice sites are vacant. Decreases density, shown by non-ionic solids.
    - **Interstitial defect :** Arises when constituent particles occupy interstitial site. Increases density, shown by non-ionic solids.
    - **Frenkel defect :** Smaller ion (usually cation) dislocates from its normal site to an interstitial site. Does not change density, shown by ionic solids, *e.g.*, ZnS, AgCl, AgBr, AgI, etc.
    - **Schottky defect :** Arises when equal number of cations and anions are missing. Decreases density, shown by ionic solids, *e.g.*, NaCl, KCl, CsCl, AgBr, etc.
  - **Impurity defects**
    Arise when foreign atoms are present at lattice site *e.g.*, $SrCl_2$, $CdCl_2$, AgCl etc.
  - **Non-stoichiometric defects**
    Disturb stoichiometry of solids.
    - **Metal excess defect**
      - **Due to anionic vacancies**
        A negative ion is missing from its lattice site, leaving a 'hole' which is occupied by an electron to maintain electrical neutrality, *e.g.*, LiCl, NaCl.
      - **Due to the presence of extra cations**
        Usually arises when metal oxides are heated, *e.g.*, ZnO.
    - **Metal deficiency defect**
      Arises when metal shows variable valency *e.g.*, Fe^{2+}, Fe^{3+}.
- **Line defects**
  Deviations from ideal arrangement in entire rows of lattice points.

SOLUTIONS

- Solutions are homogeneous mixtures of two or more than two components.
- Homogeneous mixture means all the components are uniformly distributed throughout the solution.
- A binary solution is composed of two components. Solution may also be known as ternary and quaternary when it is made up of three and four components respectively.

Different Types of Binary Solutions

Solute	Solvent	Solution	Example
Solid	Solid	Solid	Certain alloys
Liquid	Solid	Solid	Hg in Ag
Gas	Solid	Solid	H_2/Pd
Solid	Liquid	Liquid	Sugar in water
Liquid	Liquid	Liquid	Benzene + Toluene
Gas	Liquid	Liquid	O_2 in water
Solid	Gas	Gas	Carbon in air (smoke)
Liquid	Gas	Gas	Fog
Gas	Gas	Gas	Air

Concentration Terms

Name	Symbol	Formula
Mass percentage	%(*w*/*w*)	$\frac{\text{Mass of solute}}{\text{Total mass of solution}} \times 100$
Mass by volume percentage	% (*w*/*v*)	$\frac{\text{Mass of solute}}{\text{Total volume of solution (mL)}} \times 100$
Volume percentage	%(*v*/*v*)	$\frac{\text{Volume of solute}}{\text{Total volume of solution}} \times 100$

Parts per million	ppm	$\dfrac{\text{No. of parts of solute}}{\text{Total no. of parts of all components of solution}} \times 10^6$
Mole fraction	x	$x_A = \dfrac{n_A}{n_A + n_B}$
Molarity	M	$\dfrac{\text{Moles of solute}}{\text{Volume of solution in L (dm}^3)}$
Molality	m	$\dfrac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$

Solubility

The maximum amount of solute that can be dissolved in a specified amount of solvent at a specified temperature.

Solubility of a gas in liquid (Henry's law): The mass of a gas dissolved in a given volume of the liquid at constant temperature is directly proportional to the pressure of the gas present in equilibrium with the liquid.

$m = K_H P$

Factors affecting solubility of a solid in liquid

- **Nature of solute and solvent**
  Polar solutes dissolve in polar solvents and non-polar solutes in non-polar solvents.
- **Temperature**
  If the dissolution process is endothermic, solubility increases with rise in temperature. If dissolution process is exothermic, solubility decreases with rise in temperature.
- **Pressure**
  Pressure does not have any significant effect on solubility of solids in liquids as these are highly incompressible.

Ideal Solutions

The solutions which obey Raoult's law at all temperatures and concentrations are called ideal solutions.

Raoult's law states that for a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction present in solution *i.e.*, $p_1 = p_1^\circ x_1$ and $p_2 = p^\circ_2 x_2$, where p_1° and p_2° are vapour pressures of pure components 1 and 2 respectively, at the same temperature.

In ideal solution, for a binary solution of components A and B, A—B interactions are equal to A—A and B—B interactions.

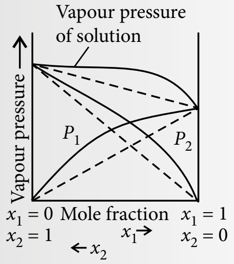
$\Delta H_{mix} = 0$ and $\Delta V_{mix} = 0$

Non-ideal Solutions

- Do not obey Raoult's law at all temperatures and concentrations.
- $p_1 \neq x_1 p_1^\circ ; p_2 \neq x_2 p_2^\circ ; \Delta H_{mix} \neq 0$ and $\Delta V_{mix} \neq 0$
- $A - B$ interactions $\neq A - A$ and $B - B$ interactions.
- Form azeotropes.

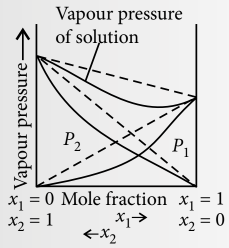
Solutions Showing Positive Deviation

- $A - B << A - A$ or $B - B$ interactions
- $\Delta H_{mix} > 0, \Delta V_{mix} > 0 ; p_i > p_i^\circ x_i$
- Form minimum boiling azeotropes
- Examples : Ethanol and acetone, carbon disulphide and acetone, methanol and water, etc.



Solutions Showing Negative Deviation

- $A - B >> A - A$ or $B - B$ interactions
- $\Delta H_{mix} < 0, \Delta V_{mix} < 0 ; p_i < p_i^\circ x_i$
- Form maximum boiling azeotropes
- Examples : Phenol and aniline, chloroform and acetone, chloroform and diethyl ether, etc.



Colligative Properties

The properties which depend on the number of solute particles irrespective of their nature relative to the total number of particles present in the solution.

Elevation in Boiling Point :

$\Delta T_b = T_b - T_b^\circ \propto m = K_b m$

$$\Delta T_b = K_b\left(\frac{W_B \times 1000}{M_B \times W_A}\right) \Rightarrow M_B = \frac{1000 \times W_B \times K_b}{\Delta T_b \times W_A}$$

K_b is called boiling point elevation constant or molal elevation constant or Ebullioscopic constant, having unit K kg mol^{-1}.

Relative lowering of Vapour Pressure :

$$\frac{p_A^\circ - p_A}{p_A^\circ} = x_B = \frac{n_B}{n_A + n_B} = \frac{n_B}{n_A} = \frac{W_B \times M_A}{M_B \times W_A}$$

($\because$ for dilute solutions, $n_B << n_A$)

Depression in Freezing Point :

$\Delta T_f = T_f^\circ - T_f \propto m = K_f m$

$$\Delta T_f = K_f\left(\frac{W_B \times 1000}{M_B \times W_A}\right)$$

$$\Rightarrow M_B = \frac{K_f \times W_B \times 1000}{\Delta T_f \times W_A}$$

K_f is known as freezing point depression constant or molal depression constant or Cryoscopic constant, having unit K kg mol^{-1}.

Osmosis and Osmotic Pressure :

$$\pi = CRT = \left(\frac{n_B}{V}\right)RT,$$

$$\pi V = \frac{W_B RT}{M_B} \text{ or } M_B = \frac{W_B RT}{\pi V}$$

van't Hoff Factor

- $$i = \frac{\text{Observed value of the colligative property}}{\text{Calculated value of the colligative property}}$$
- $$= \frac{\text{Calculated molecular mass}}{\text{Observed molecular mass}}$$
- $$i = \frac{\text{Total number of moles of particles after association/dissociation}}{\text{Number of moles of particles before association/dissociation}}$$

For association, $i < 1$; For dissociation, $i > 1$

- **Relation between van't Hoff factor and degree of dissociation :** $\alpha = \dfrac{i-1}{n-1}$
- **Relation between van't Hoff factor and degree of association :** $\alpha = \dfrac{1-i}{1-1/n}$
- **Modified equations for colligative properties :**

$$\frac{p_A^\circ - p_A}{p_A^\circ} = i \cdot \frac{n_B}{n_A},$$

$\Delta T_b = iK_b m$, $\Delta T_f = iK_f m$, $\pi = i\, n_B RT/V$

SPEED PRACTICE

1. A hard, crystalline solid with a high melting point does not conduct electricity in any phase. This solid is most likely
(a) an ionic solid
(b) a metallic solid
(c) a molecular solid
(d) a network covalent solid.

2. Which of the following options does not represent concentration of semi-molal aqueous solution of NaOH having $d_{\text{solution}} = 1.02$ g/mL?
(a) Molarity $= \frac{1}{2}$ M
(b) $X_{\text{NaOH}} = \frac{9}{1009}$
(c) % w/w = 10%
(d) % w/v = 2%

3. The crystal system of a compound with unit cell dimensions a = 0.387 nm, b= 0.387 nm and c = 0.504 nm and $\alpha = \beta = 90°$ and $\gamma = 120°$ is
(a) cubic
(b) hexagonal
(c) orthorhombic
(d) rhombohedral.

4. A solution of A and B with 30% moles of A in solution is in equilibrium with its vapour which contains 60% moles of A. What will be the ratio of the vapour pressure of pure A to that of pure B? (Assume ideal nature)
(a) 1.5 (b) 2.5 (c) 3.5 (d) 4.5

5. The density of KCl is 1.9893 g cm^{-3} and the edge length of unit cell is 6.29082 Å as determined by X-rays diffraction. The value of Avogadro's number calculated from these data is
(a) 6.021×10^{23} (b) 6.023×10^{23}
(c) 6.03×10^{23} (d) 6.017×10^{19}

6. When 1.9 g of a substance is dissolved in 128 g water, freezing point of solution is depressed by –0.35 °C. Calculate molecular mass of the substance. (K_f of water is 1.86 K kg mol^{-1}.)
(a) 58.12 (b) 69.32
(c) 78.88 (d) 101.25

7. An oxide of rhenium crystallises with eight rhenium atoms at the corners of the unit cell and 12 oxygen atoms on the edges between them. What is the formula of this oxide?
(a) ReO (b) Re_2O_3
(c) ReO_2 (d) ReO_3

8. 200 mL of a very dilute aqueous solution of a protein contains 1.9 g of the protein. If osmotic rise of such a solution at 300 K is found to be 38 mm of solution then calculate molar mass of the protein.
(a) 24630 g/mol (b) 123150 mg/mol
(c) 517230 g/mol (d) 63644 g/mol

9. Sodium metal crystallises in a body centred cubic lattice with the cell length (a) = 4.29 Å. The radius of sodium atom (in Å) is
(a) 1.8576 (b) 2.8576
(c) 3.8576 (d) none of these.

10. The vapour pressure of pure benzene at 25 °C is 639.7 mm of Hg and the vapour pressure of a solution of a solute in C_6H_6 at the same temperature is 631.9 mm of Hg. The molality of solution is
(a) 0.269 (b) 0.158 (c) 0.486 (d) 0.108

11. A metal crystallises into two cubic phases, face-centred cubic (*fcc*) and body-centred cubic (*bcc*) whose unit cell lengths are 3.5 Å and 3.0 Å, respectively. Calculate the ratio of densities of *fcc* to *bcc*.
(a) 1.259 (b) 1.871 (c) 2.112 (d) 0.115

12. At 27 °C, 1.25 L of a solution containing 7.6 g KBr shows an osmotic pressure of 1.804 atm. What is the value of van't Hoff factor?
(a) 1.4 (b) 1.8 (c) 2.1 (d) 0.8

13. Platinum crystallises in a face centered cubic crystal with a unit cell length of 3.9231 Å. The density and atomic radius of platinum are respectively
(a) 45.25 g cm^{-3}, 2.516 Å
(b) 21.45 g cm^{-3}, 1.387 Å
(c) 29.46 g cm^{-3}, 1.48 Å
(d) none of the above.

14. The Henry's law constant for the solubility of N_2 gas in water at 298 K is 1.0×10^5 atm. The mole fraction of N_2 in air is 0.8. The number of moles of N_2 from air dissolved in 10 moles of water at 298 K and 5 atm pressure is
(a) 4.0×10^{-4} (b) 4.0×10^{-5}
(c) 5.0×10^{-4} (d) 4.0×10^{-6}

15. Total number of voids in 0.5 mole of a compound forming hexagonal closed packed structure are
(a) 6.022×10^{23} (b) 3.011×10^{23}
(c) 9.034×10^{23} (d) 4.516×10^{23}

16. At 27 °C, 36 g of glucose per litre has an osmotic pressure of 4.92 atm. If the osmotic pressure of another glucose solution is 1.5 atm at the same temperature. What should be its concentration?
(a) 1.23 M (b) 5.86 M
(c) 0.061 M (d) 0.21 M

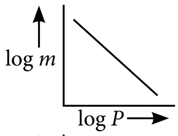
17. Normal boiling point (T_N) is defined as the temperature when vapour pressure of liquid becomes equal to 1 atm and standard boiling point (T_S) is defined as the temperature when vapour pressure of liquid becomes equal to 1 bar. Which one is not correct if water is considered?
(a) T_N = 100 °C (b) T_S > 1000 °C
(c) T_S < 100 °C (d) $T_S < T_N$

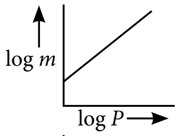
18. In case of osmosis, solvent molecules move from
(a) higher vapour pressure to lower vapour pressure
(b) higher concentration to lower concentration
(c) lower vapour pressure to higher vapour pressure
(d) higher osmotic pressure to lower osmotic pressure.

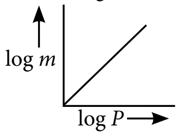
19. Conduction in a p-type semiconductor is increased by

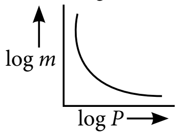
(a) increasing the band gap
(b) decreasing the temperature
(c) adding appropriate electron deficient impurities
(d) adding appropriate electron rich impurities.

20. According to William Henry, the solubility of a gas in liquid depends on the pressure of the gas. If 'm' is the molality of the gas and 'P' is its pressure, then which of the following plot is in accordance with the law?

(a) 

(b) 

(c) 

(d) 

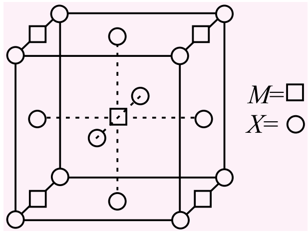
21. A non-stoichiometric compound $Cu_{1.8}S$ is formed due to incorporation of Cu^{2+} ions in the lattice of cuprous sulphide. What percentage of Cu^{2+} ion in the total copper content is present in the compound?
(a) 88.88 (b) 11.11 (c) 99.8 (d) 89.8

22. A very small amount of a non-volatile solute (that does not dissociate) is dissolved in 56.8 cm^3 of benzene (density 0.889 g cm^{-3}). At room temperature, vapour pressure of this solution is 98.88 mm Hg while that of benzene is 100 mm Hg. Find the molality of this solution.
(a) 0.1452 m (b) 0.73 m
(c) 2.591 m (d) 5.028 m

23. If sphere of radius 'r' are arranged in a ccp fashion ($ABCABC$...), then the vertical distance between any two consecutive A layers is
(a) $4r\sqrt{\frac{2}{3}}$ (b) $4r\sqrt{\frac{3}{2}}$ (c) $6r$ (d) $r\sqrt{6}$

24. A maxima or minima obtained in the temperature, composition curve of a mixture of two liquids indicates
(a) an azeotropic mixture
(b) an eutectic formation
(c) that the liquids are immiscible with one another
(d) that the liquids are partially miscible at the maximum or minimum.

25. A compound M_pX_q has cubic close packing (ccp) arrangement of X. Its unit cell structure shown below. The empirical formula of the compound is



(a) MX (b) MX_2 (c) M_2X (d) M_5X_{14}

SOLUTIONS

1. (d)

2. (c) : Semi-molal $\Rightarrow \frac{1}{2}$m

d = 1.02 g/mL

1 kg of water contains $\frac{1}{2}$ mole of NaOH *i.e.*, 20 g

Mass of solution = 1000 + 20 = 1020 g

Volume of solution $= \frac{1020}{1.02} = 1000 \text{ mL} = 1 \text{ L}$

$$M = \frac{\frac{1}{2}}{1} = \frac{1}{2}\ ;\ X_{NaOH} = \frac{\frac{1}{2}}{\frac{1}{2}+\frac{1000}{18}} = \frac{9}{1009}$$

$$\%w/w = \frac{20}{1020}\times 100 = 2\%\quad \%w/v = \frac{20}{1000}\times 100 = 2\%$$

3. (b)

4. (c) : $P_A^\circ \cdot X_{A(LP)} = P_M \cdot X'_{A(VP)}$

$$P_A^\circ \times \frac{30}{100} = P_M \times \frac{60}{100}\ ;\ P_B^\circ \times \frac{70}{100} = P_M \times \frac{40}{100}$$

$$\therefore\ \frac{P_A^\circ}{P_B^\circ}\times\frac{30}{70} = \frac{60}{40}\quad \therefore\ \frac{P_A^\circ}{P_B^\circ} = \frac{60\times 70}{30\times 40} = 3.5$$

5. (a) : Density of KCl = 1.9893 g/cm^3
a = 6.29082 Å = 6.29082 × 10^{-8} cm
Mol. wt. of KCl = 74.55 N_A = ?
Since, KCl crystallises in the NaCl type structure, it has fcc lattice. Hence, there are four atoms per unit cell.

$$d = \frac{Z\times M}{a^3\times N_A} \Rightarrow 1.9893 = \frac{4\times 74.55}{(6.29082)^3\times 10^{-24}\times N_A}$$

$N_A = 6.021 \times 10^{23}$

6. (c) : Since, molar depression constant,
K_f = 1.86 K kg mol^{-1}

$$\Delta T_f = \frac{1000K_f\times w}{M\times W}$$

Given that, w = 1.9 g, W = 128 g,

$\Delta T_f = 0 - (-0.35) = 0.35$ K

$\therefore \quad 0.35 = \dfrac{1000 \times 1.86 \times 1.9}{M \times 128} \Rightarrow M = 78.88$

7. **(d)**

8. **(d):** Osmotic rise in terms of mm of Hg = $\dfrac{38}{13.6}$

Now, $\pi = CRT$;

$$\frac{38}{13.6} \times \frac{1}{760} = \left(\frac{\frac{1.9}{M}}{200} \times 1000 \right) \times 0.0821 \times 300$$

$\Rightarrow \quad M = 63644$ g/mol

9. **(a):** Radius of Na (for *bcc* lattice)

$= \dfrac{\sqrt{3}}{4} a = \dfrac{\sqrt{3} \times 4.29}{4} = 1.8576$ Å

10. **(b):** $\because \dfrac{P° - P_s}{P_s} = \dfrac{w \times M}{m \times W}$

$\therefore \quad$ Molality $= \dfrac{w}{m \times W} \times 1000 = \dfrac{P° - P_s}{P_s \times M} \times 1000$

$= \dfrac{639.7 - 631.9}{631.9 \times 78} \times 1000 = 0.158$ mol/kg

11. **(a):** *fcc* unit cell length = 3.5 Å

bcc unit cell length = 3.0 Å

Density = $\dfrac{Z \times \text{at. wt.}}{V \times \text{Av. no.}}$

$$\frac{d_{fcc}}{d_{bcc}} = \frac{Z_1}{Z_2} \times \frac{V_2}{V_1}$$

Now, Z_1 for *fcc* = 4 ; Also, $V_1 = a^3 = (3.5 \times 10^{-8})^3$

Z_2 for *bcc* = 2 ; Also, $V_2 = a^3 = (3.0 \times 10^{-8})^3$

$$\frac{d_{fcc}}{d_{bcc}} = \frac{4 \times (3.0 \times 10^{-8})^3}{2 \times (3.5 \times 10^{-8})^3} = 1.259$$

12. **(a):** $\pi_{th} = \dfrac{n}{V} RT = \dfrac{7.6}{119} \times \dfrac{1}{1.25} \times 0.0821 \times 300$

$\pi_{th} = 1.258$ atm and $\pi_{exp.} = 1.804$ atm

$\therefore \quad i = \dfrac{\pi_{exp.}}{\pi_{th}} = \dfrac{1.804}{1.258} = 1.4$

13. **(b):** $d = \dfrac{4 \times 195}{(3.9231 \times 10^{-8})^3 \times 6.023 \times 10^{23}}$

$= 21.45$ g cm^{-3}

$r = \dfrac{a}{2\sqrt{2}} = \dfrac{3.9231}{2\sqrt{2}} = 1.387$ Å

14. **(a):** According to Henry's law

$x_{N_2} \times K_H = p_{N_2}$ (p_{N_2} = Partial pressure of N_2)

Given, total pressure = 5 atm, mole fraction of $N_2 = 0.8$

$\therefore \quad$ partial pressure of $N_2 = 0.8 \times 5 = 4$

$\Rightarrow \quad x_{N_2} \times 1 \times 10^5 = 4 \quad \Rightarrow \quad x_{N_2} = 4 \times 10^{-5}$

no. of moles of H_2O, $n_{H_2O} = 10$

no. of moles of N_2, $n_{N_2} = ?$

$$\frac{n_{N_2}}{n_{N_2} + n_{H_2O}} = x_{N_2} \Rightarrow \frac{n_{N_2}}{10 + n_{N_2}} = 4 \times 10^{-5}$$

$\Rightarrow \quad n_{N_2} = 4 \times 10^{-4} \qquad (\because n_{N_2} <<<< 10)$

15. **(c):** Number of close packed particles

$= 0.5 \times 6.023 \times 10^{23}$

$\therefore \quad$ Number of octahedral voids $= 3.0115 \times 10^{23}$

Number of tetrahedral voids $= 2 \times 3.0115 \times 10^{23}$

$= 6.023 \times 10^{23}$

Therefore, total no. of voids $= 6.023 \times 10^{23}$

$+ 3.0115 \times 10^{23} = 9.0345 \times 10^{23}$

16. **(c):** $\pi V = nRT$

Using the given data, $\pi_1 = 4.92$ atm, $\pi_2 = 1.5$ atm

$C_1 = \dfrac{36}{180 \times 1}$, $C_2 = ? \qquad \left(\because C = \dfrac{w}{M \times V}\right)$

$\pi_1 V_1 = n_1 RT_1$; $\pi_2 V_2 = n_2 RT_2$

$\dfrac{\pi_1}{\pi_2} = \dfrac{n_1}{V_1} \times \dfrac{V_2}{n_2} = \dfrac{C_1}{C_2} \qquad$ (If $T_1 = T_2$)

$\therefore \quad \dfrac{4.92}{1.5} = \dfrac{36}{180 \times C_2} \Rightarrow C_2 = 0.061$ mol/L

17. **(b)** **18.** **(a)**

19. **(c):** Adding electron deficient impurities creates an abundance of holes. These holes are majority carriers in *p*-type semiconductors and are responsible for conduction.

20. **(b):** $m = KP$

$\ln m = \ln P + \ln K$; $\log m = \log P + \log K$

Comparing with $y = mx + c$ we get graph given in option (b).

21. **(b):** Let x Cu^{2+} and $(1.8 - x)Cu^+$ ions are present in the compound $Cu_{1.8}S$. Compound is electrically neutral.

$\therefore \quad 2x + (1.8 - x) - 2 = 0 \Rightarrow x = 0.2$

% $Cu^{2+} = \dfrac{0.2}{1.8} \times 100 = 11.11$

22. **(a):** $\dfrac{P° - P_s}{P_s} = \dfrac{w}{m} \times \dfrac{M}{W} \quad \therefore \quad \dfrac{100 - 98.88}{98.88} = \dfrac{w \times 78}{m \times W}$

or, molality $\left(\dfrac{w \times 1000}{m \times W}\right) = \dfrac{1.12 \times 1000}{78 \times 98.88} = 0.1452$ m

23. **(b):** Because $a\sqrt{2} = 4r \quad \Rightarrow \quad a\sqrt{3} = 4r\sqrt{\dfrac{3}{2}}$

24. **(a)** **25.** **(b)**

◈◈

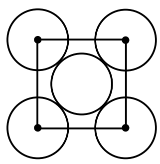
Class XII

Be NEET READY

with exclusive and brain storming MCQs

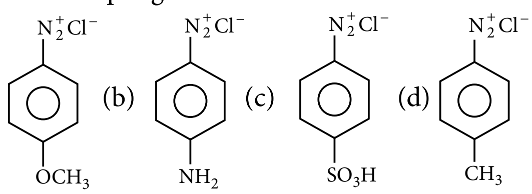
Practicing these MCQs helps to strengthen your concepts and give you extra edge in your NEET preparation

1. The packing efficiency of the two dimensional square unit cell shown below is



(a) 50.25%
(b) 68.0 2%
(c) 74.05%
(d) 78.50%

2. Which of the following compounds is most suitable for diazo coupling reaction?



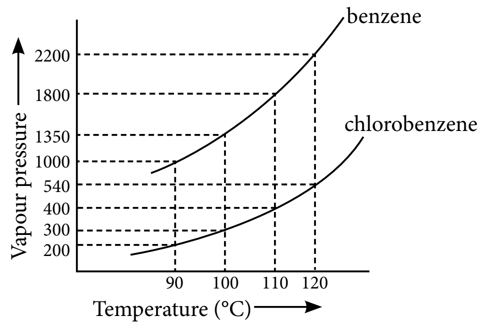
3. In which of the following reactions coloured gas is a product?

(a) $H_3PO_3 \xrightarrow{\Delta}$
(b) $O_3 + KI \xrightarrow{\text{Neutral solution}}$
(c) $HBr + H_2SO_4$ (conc.) $\longrightarrow$
(d) All of these

4. An aqueous solution freezes at –0.186 °C (K_f = 1.86, K_b = 0.512). What is the elevation in boiling point?

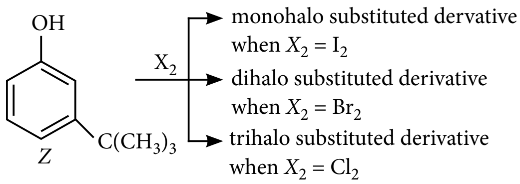
(a) 0.512 (b) 0.0512
(c) 0.186 (d) 0.0186

5. Assuming the formation of an ideal solution, determine the boiling point of a mixture containing 1560 g benzene and 1125 g chlorobenzene using the following graph against an external pressure of 1000 torr.



(a) 120 °C (b) 110 °C (c) 100 °C (d) 90 °C

6. The reactivity of compound Z with different halogens under appropriate conditions is given below



The observed pattern of electrophilic substitution cannot be explained by

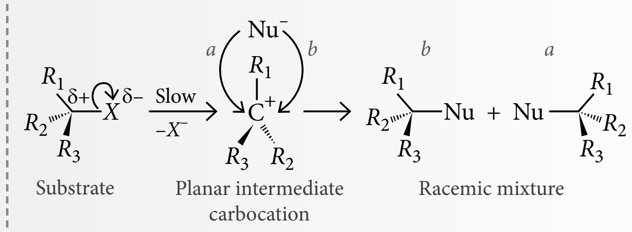
(a) the steric effect of the halogen
(b) the steric effect of the *tert*-butyl group
(c) the electronic effect of the phenolic group
(d) the electronic effect of the *tert*-butyl group.

CONCEPT MAP

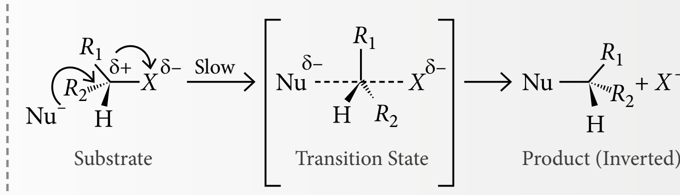
HALOALKANES AND HALOARENES

Nucleophilic Substitution Reactions

S_N1 (Racemisation)



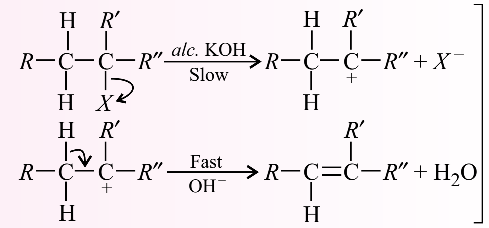
S_N2 (Inversion of Configuration)



Elimination Reactions

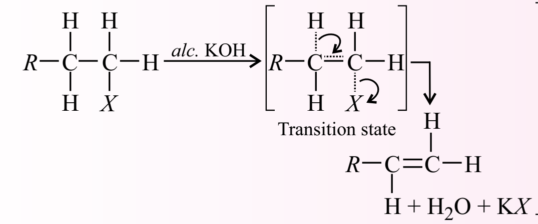
Alkyl halides undergo β-elimination reaction in the presence of potassium hydroxide in ethanol (high temperature) to yield alkenes.

E1 mechanism



Rate = k [Alkyl halide]

E2 mechanism



Rate = k [Alkyl halide] [base]

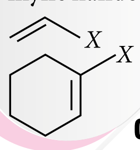
1 Classification

On the basis of number of halgoen atoms

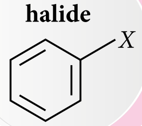
- Monohalogen e.g., RCH_2X
- Dihalogen e.g., $X-CH_2CH_2-X$
- Trihalogen e.g., CHX_3

Compounds containing sp^2 C—X bond

- Vinylic halide

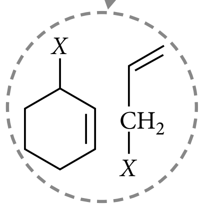


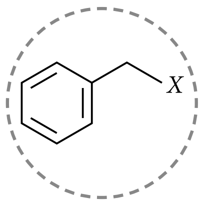
- Aryl halide



Compounds containing sp^3 C—X bond

- Haloalkanes $R—X$
- Allylic halide
- Benzylic halide





2 Nature of C—X Bond

$\overset{\delta+}{C}—\overset{\delta-}{X}$

C—F, C—Cl, C—Br, C—I $\longrightarrow$

Size of halogen atoms increases
C—X bond length increases
Bond enthalpy decreases

3 Methods of Preparation

Alkyl halide

◆ **From Alkanes :**

$RH \xrightarrow{\text{By halogenation}}$
- $\xrightarrow{Br_2, AlBr_3} R—Br + HBr$
- $\xrightarrow{Cl_2, \text{ Sunlight}} R—Cl + HCl$

◆ **From Alcohols :**

$R—OH$
- $\xrightarrow{PCl_5} R—Cl + POCl_3 + HCl$
- $\xrightarrow{\text{Red P}/Br_2} R—Br + H_3PO_3$
- $\xrightarrow[\text{Pyridine}]{SOCl_2} R—Cl + SO_2\uparrow + HCl\uparrow$

◆ **Finkelstein Reaction :** $R—X + NaI \xrightarrow{\text{Dry acetone}} R—I + NaX$

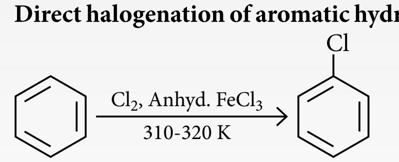
◆ **Swarts Reaction :** $RBr + AgF \longrightarrow R—F + AgBr$

◆ **Hunsdiecker Reaction :**

$RCOOAg + Br_2 \xrightarrow{CCl_4/\text{Reflux}} R—Br + CO_2 + AgBr$

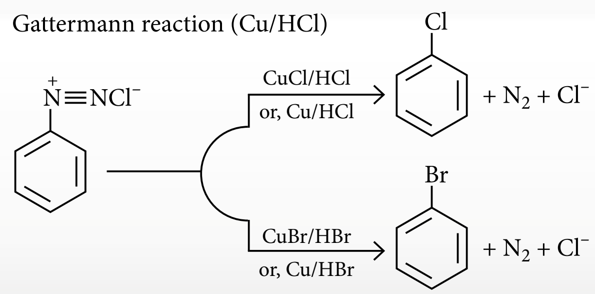
Aryl halide

◆ **Direct halogenation of aromatic hydrocarbons :**



◆ **From diazonium salts :**

Sandmeyer's reaction (CuCl/HCl) and
Gattermann reaction (Cu/HCl)



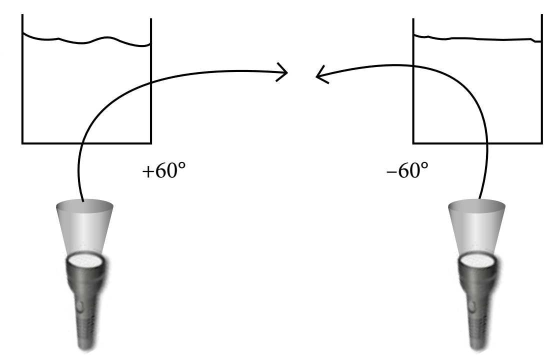
4 Chemical Properties

5 Stereochemistry

Optical Activity

Plane polarised light produced by passing ordinary light through nicol prism is rotated when it is passed through the solutions of certain compounds. Such compounds are called optically active compounds.

Chirality : The objects which are non-superimposable on their mirror images are said to be chiral.

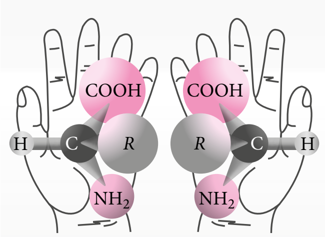


Clockwise rotation = dextrorotatory (d) or (+)

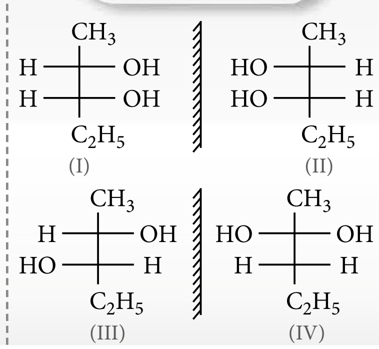
Counterclockwise rotation = laevorotatory (l) or (−)

The direction and magnitude of rotation must be determined experimentally. There is no correlation between (R) and (S) configuration and the direction of rotation.

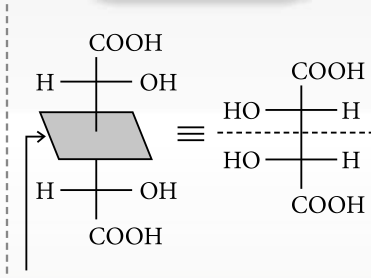
Enantiomers : Compounds having non-superimposable mirror images with same physical and chemical properties.



Diastereomers : Compounds which are not mirror images (I and III, II and IV) of each other with different physical properties but same chemical properties.



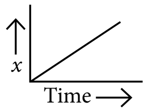
Meso compounds : These are optically inactive compounds as there exists a plane of symmetry which divides the molecule into two identical halves.



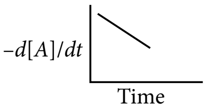
Racemic mixture : A mixture of equal amounts of two enantiomers is called *racemic mixture* or *racemic modification*.

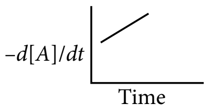
A racemic mixture is always optically inactive because the rotation caused by the molecules of one enantiomer is exactly cancelled by equal and opposite rotation caused by the same number of molecules of the other enantiomer. It is represented by prefixing dl or (±) before the name. For example, (±) butan-2-ol.

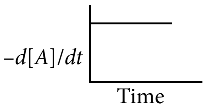
7. Graph between concentration of the product and time of the reaction ($A \rightarrow B$) is shown as :

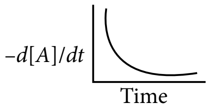


Then, graph between $-d[A]/dt$ and time will be of the type

(a) 

(b) 

(c) 

(d) 

8. Which of the following gives three mole of AgBr with excess $AgNO_3$ solution?

(a) $[Co(NH_3)_6]Br_3$ (b) $[Co(NH_3)_3Br_3]$
(c) $[Co(NH_3)_4Br_2]Br$ (d) $[Co(NH_3)_5Br]Br_2$

9. 0.1 molar NaCl solution is filled in different conductivity cells.

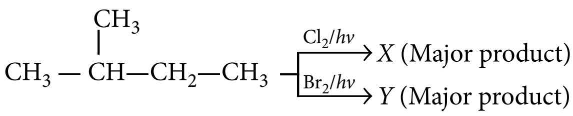
	Cell – 1	**Cell – 2**	**Cell – 3**
Area of cross section (A)	5 cm^2	7.5 cm^2	10 cm^2
Distance between two electrodes (l)	2 cm	3 cm	4 cm

Order of equivalent conductance of NaCl solution is

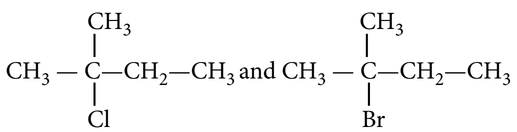
(a) Cell – 1 > Cell – 2 > Cell – 3
(b) Cell – 1 = Cell – 2 = Cell – 3
(c) Cell – 1 > Cell – 3 > Cell – 2
(d) Cell – 3 > Cell – 2 > Cell – 1

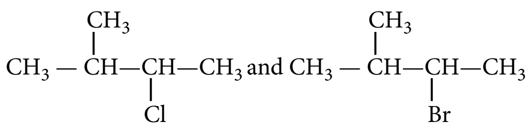
10. A mineral is called ore if

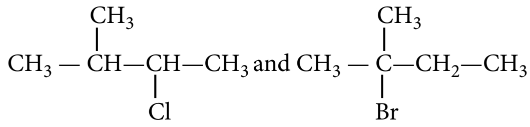
(a) metal present in the mineral is costly
(b) a metal can be extracted from it
(c) a metal can be extracted profitably from it
(d) a metal cannot be extracted from it.

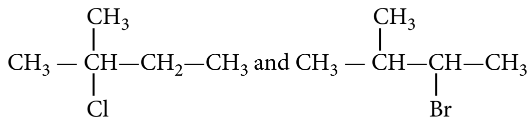
11. 

X and Y are respectively

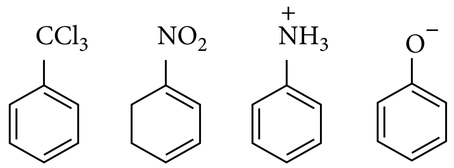
(a) 

(b) 

(c) 

(d) 

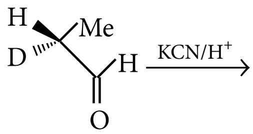
12. In which of the following, NO_2^+ will attack at m-position?



(I) (II) (III) (IV)

(a) I, II, and III (b) II and IV
(c) II and III only (d) I only

13. The number of products formed in the following reaction is

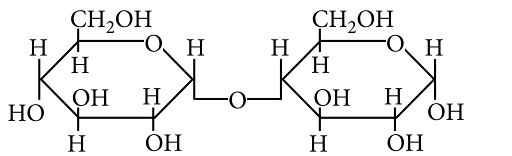


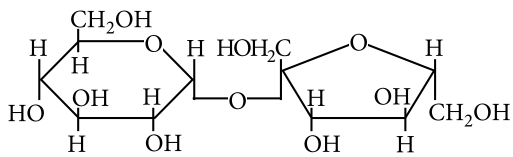
(a) 1 (b) 2 (c) 3 (d) 4

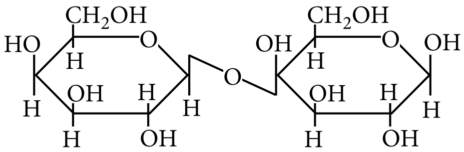
14. In acidic medium $KMnO_4$ oxidises $FeSO_4$ solution. Which of the following statements is correct?

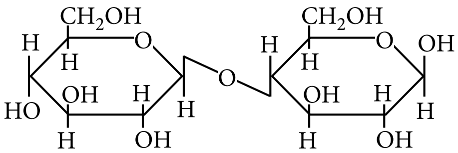
(a) 10 mL of 1N $KMnO_4$ solution oxidises 10 mL of 5N $FeSO_4$ solution.
(b) 10 mL of 1M $KMnO_4$ solution oxidises 10 mL of 5N $FeSO_4$ solution.
(c) 10 mL of 1M $KMnO_4$ solution oxidises 10 mL of 1M $FeSO_4$ solution.
(d) 10 mL of 1N $KMnO_4$ solution oxidises 10 mL of 0.1M $FeSO_4$ solution.

15. Which of the following disaccharides is non-reducing in nature?

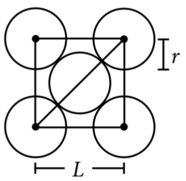
(a) 

(b) 

(c) 

(d) 

SOLUTIONS

1. **(d) :** 

$4r = L\sqrt{2}$ so, $L = 2\sqrt{2}r$

Area of square unit cell = $(2\sqrt{2}r)^2 = 8r^2$

Area of atoms present in one unit cell

$= \pi r^2 + 4\left(\frac{\pi r^2}{4}\right) = 2\pi r^2$

so, packing efficiency = $\frac{2\pi r^2}{8r^2} \times 100$

$= \frac{\pi}{4} \times 100 = 78.5\%$

2. **(c) :** The aryl diazonium ion (ArN_2^+) functions as electrophile, so presence of electron withdrawing group ($-SO_3H$) increases its electrophilicity. Diazocoupling is possible only in strongly activated rings.

3. **(c) :** $4H_3PO_3 \xrightarrow{\Delta} 3H_3PO_4 + PH_3$

$2I^- + H_2O + O_3 \longrightarrow 2OH^- + I_{2(s)} + O_{2(g)}$

$HBr + H_2SO_4 \longrightarrow \underset{\text{(Reddish brown)}}{Br_{2(g)}} + SO_2 + H_2O$

4. **(b) :** $\Delta T_f = K_f \times m$

or, $0.186 = 1.86 \times m$ or $m = 0.1$

$\Delta T_b = K_b \times m = 0.512 \times 0.1 = 0.0512$

5. **(c) :** Moles of benzene (n_B) = $\frac{1560}{78} = 20$

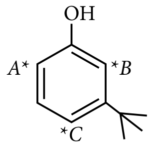
Moles of chlorobenzene (n_C) = $\frac{1125}{112.5} = 10$

$X_B = \frac{2}{3}, X_C = \frac{1}{3}$

At $t = 100\ °C$

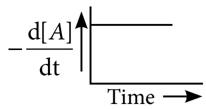
$P_s = p_B^\circ X_B + p_C^\circ X_C$

$P_s = 1350 \times \frac{2}{3} + 300 \times \frac{1}{3}$ = 1000 torr

6. **(d) :** 

—OH group is strongly activating and o/p-directing due to its powerful $+M$ effect.
With I_2 only A is substituted, since I is large and also steric inhibition by large $-CMe_3$ group forbids substitution at B or C.
Br_2 and Cl_2 become progressively more reactive, due to
(i) Increasing electrophilic nature of X^+ (not mentioned in any option).
(ii) Smaller size, most sterically hindered location is B which is substituted only by –Cl.

7. **(c) :** From given graph $x = kt$
i.e., it is a zero order reaction.



$\therefore \quad -\frac{d[A]}{dt} = k$

8. **(a) :** $[Co(NH_3)_6]Br_3 \xrightleftharpoons{aq.} [Co(NH_3)_6]^{3+} + 3Br^-$

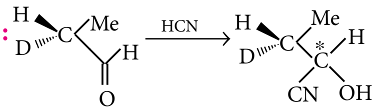
$3Ag^+ + 3Br^- \longrightarrow 3AgBr\downarrow$ (yellow)

9. **(b) :** $\Lambda_{eq} = \frac{\kappa \times 1000}{\text{Normality}}$

and $\kappa \propto \frac{l}{A}$ $\qquad \left[\frac{l}{A} = \text{cell constant}\right]$

10. **(c)** 11. **(c)**

12. **(a) :** $-CCl_3$, $-NO_2$ and $\overset{+}{N}H_3$ are *meta* directing in nature.

13. **(b) :** 

2 isomers
(Diastereomers)

14. **(b) :** $2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$

1 M $KMnO_4 \equiv$ 5N $KMnO_4 \equiv$ 5N$FeSO_4$

$\therefore \quad \underset{(KMnO_4)}{10 \times 1M} \equiv \underset{(KMnO_4)}{10 \times 5N} \equiv \underset{(FeSO_4)}{10 \times 5N}$

15. **(b)**

◈◈

MONTHLY TUNE UP CLASS XII ANSWER KEY

1. (d)	2. (b)	3. (c)	4. (c)	5. (a)
6. (a)	7. (b)	8. (c)	9. (c)	10. (b)
11. (a)	12. (c)	13. (a)	14. (d)	15. (c)
16. (c)	17. (b)	18. (a)	19. (d)	20. (b,d)
21. (a,b,c,d)	22. (c,d)	23. (b,c)	24. (0.6)	25. (2)
26. (2.91)	27. (c)	28. (c)	29. (a)	30. (b)

CLASS XII

CBSE DRILL

Chapterwise practice questions for CBSE Exams as per the latest pattern and marking scheme issued by CBSE for the academic session 2018-19.

GENERAL INSTRUCTIONS

(i) All questions are compulsory.
(ii) Q. no. 1 to 5 are very short answer questions and carry 1 mark each.
(iii) Q. no. 6 to 12 are short answer questions and carry 2 marks each.
(iv) Q. no. 13 to 24 are also short answer questions and carry 3 marks each.
(v) Q. no. 25 to 27 are long answer questions and carry 5 marks each.
(vi) Use log tables if necessary, use of calculator is not allowed.

Time Allowed : 3 hours | Maximum Marks : 70

Electrochemistry | Chemical Kinetics| Surface Chemistry

1. Explain why the rate of a reaction in the remaining mixture is not affected when a portion is removed for analysis.

2. Solutions of two electrolytes A and B are diluted. The Λ_m of 'B' increases 1.5 times while that of A increases 25 times. Which of the two is a strong electrolyte ? Justify your answer.

3. Name one each of positively and negatively charged colloidal particles.

4. For a reaction $A + B \rightarrow P$, the rate law is given by,
$r = k[A]^{1/2}[B]^2$
What is the order of this reaction?

5. How is adsorption of a gas related to its critical temperature?

6. Calculate the equilibrium constant for the reaction.
$Cu_{(s)} + 2Ag^+_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$ ($E^\circ_{cell} = 0.46$ V)
($T = 298$ K, $F = 96,500$ C mol^{-1}, $R = 8.31$ J K^{-1} mol^{-1})

7. Answer the following :
(a) Transition elements are good catalysts, why?
(b) How do the free valencies present on the surface of catalyst help in catalysis?

8. (a) For a certain reaction large fraction of molecules has energy more than the threshold energy, yet the rate of reaction is very slow. Why?
(b) For a zero order reaction will the molecularity be equal to zero? Explain.

9. The conductivity of a 0.12 N solution of an electrolyte of the type M^+/A^- is 0.024 S cm^{-1}. Calculate its (a) equivalent conductivity (b) molar conductivity.

10. The gas phase decomposition of acetaldehyde,
$CH_3CHO_{(g)} \longrightarrow CH_{4(g)} + CO_{(g)}$
follows the rate expression :
Rate $= -[CH_3CHO] / dt = k[CH_3CHO]^{3/2}$
In terms of the partial pressure of acetaldehyde, it can be expressed as

$$-\frac{dp_{CH_3CHO}}{dt} = k(p_{CH_3CHO})^{3/2}$$

If the pressures is measured in the units of atmosphere and time in minutes then,

(a) what is the unit of rate of reaction?

(b) what is the unit of the rate constant, k?

OR

The rate constant for a first order reaction is 60 s^{-1}. How much time will it take to reduce the initial concentration of the reactant to its 1/16th value?

11. For the coagulation of 100 mL of arsenious sulphide sol, 5 mL of 1 M NaCl is required. What is the flocculation value of NaCl?

12. **(a)** On electrolysis of an aqueous solution of NaCl, why H_2 and not Na is liberated at the cathode?

(b) One faraday of electricity deposits one mole of Na from the molten salt but $\frac{1}{3}$ mol of Al from an aluminium salt. Why?

13. The decomposition of Cl_2O_7 at 400 K in the gas phase to Cl_2 and O_2 is of 1st order. After 55 sec at 400 K, the pressure of Cl_2O_7 falls from 0.062 to 0.044 atm, calculate

(a) the rate constant

(b) pressure of Cl_2O_7 after 100 sec.

14. An aqueous solution of $AuCl_3$ was electrolysed with a current of 0.5 A until 1.20 g of gold had been deposited on the cathode. At another electrode in series with this, the only reaction was the evolution of O_2. Find,

(a) number of moles of oxygen

(b) the number of coulombs passed through the solution

(c) the duration of electrolysis.

15. **(a)** How do size of particles of adsorbent, pressure of gas and prevailing temperature influence the extent of adsorption of a gas on a solid?

(b) What type of colloidal sols are formed in the following?

(i) Sulphur vapours are passed through cooled water.

(ii) White of an egg is mixed with water.

(iii) Soap solution.

16. **(a)** Calculate the standard EMF of a cell which involves the following cell reaction,

$Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$

Given, $E^\circ_{Zn|Zn^{2+}} = 0.76$ V and $E^\circ_{Ag|Ag^+} = -0.80$ V

(b) A cell consists of two hydrogen electrodes. The negative electrode is in contact with a solution having 10^{-6} M H^+ ion concentration. Calculate the concentration of H^+ ions at the positive electrode, if the emf of the cell is found to be 0.118 V at 298 K.

17. Answer the following :

(a) What is instantaneous rate of reaction?

(b) A reaction is of second order with respect to its reactant. How will its reaction rate be affected if the concentration of the reactant is (i) doubled (ii) reduced to half?

18. Answer the following :

(a) What do you understand by shape selective catalysis?

(b) Why are zeolites good shape selective catalysts?

(c) What is the difference between enzyme catalyst and other catalysts?

OR

(a) Why does physisorption decrease with the increase of temperature?

(b) Why is it essential to wash the precipitate with water before estimating it quantitatively?

(c) Give reason why a finely divided substance is more effective as an adsorbent.

19. For the reaction,

$2AgCl_{(s)} + H_{2(g)}$ (1 atm) $\rightarrow 2Ag_{(s)} + 2H^+$ (0.1 M) $+ 2Cl^-$(0.1 M)

$\Delta G^\circ = -43600$ J at 25 °C.

Calculate the e.m.f. of the cell.

20. **(a)** Define activation energy of a reaction.

(b) In general it is observed that the rate of a chemical reaction doubles with every 10° rise in temperature. If this generalization holds for a reaction in the temperature range 295 K to 305 K, what would be the value of activation energy for this reaction?

21. Give any three methods for preparation of colloids.

22. From the following data, show that the decomposition of hydrogen peroxide is a reaction of first order :

t	0	10	20
x	46.1	29.8	19.3

where, t is the time in minute and x is the volume of the standard $KMnO_4$ solution in cm^3 required for titrating the same volume of the reaction mixture.

23. When a certain conductance cell was filled with 0.1 M KCl, it has a resistance of 85 ohms at 25°C.

When the same cell was filled with an aqueous solution of 0.052 M unknown electrolyte, the resistance was 96 ohms. Calculate the molar conductance of the electrolyte at this concentration.
(Specific conductance of 0.1 M KCl
$= 1.29 \times 10^{-2}$ ohm^{-1} cm^{-1})

24. Give reasons for the following observations :

(a) Peptizing agent is added to convert precipitate into colloidal solution.

(b) Cottrell's smoke precipitator is fitted at the mouth of the chimney used in factories.

(c) Colloidal gold is used for intramuscular injection.

25. For the reaction, $2A + B_2 \longrightarrow 2AB$, following observations were obtained :

Rate of disappearance of B_2 (mol L^{-1}s^{-1})	$[A]$ (mol L^{-1})	$[B_2]$ (mol L^{-1})
1.8×10^{-3}	0.015	0.15
1.085×10^{-2}	0.090	0.15
5.4×10^{-3}	0.015	0.45

Find out the following :

(a) order of reaction

(b) rate constant

(c) rate of formation of AB, when $[A] = 0.02$ and $[B_2] = 0.04$ mol L^{-1}

OR

Answer the following :

(a) A first order reaction has a specific reaction rate of 10^{-3} sec^{-1}. How much time will it take for 10 g of the reactant to reduce to 2.5 g ? (Given, log 2 = 0.301, log 4 = 0.6021, log 6 = 0.778)

(b) The rate constant for an isomerisation reaction, $A \longrightarrow B$ is 4.5×10^{-3} min^{-1}. If the initial concentration of A is 1 M, calculate the rate of reaction after 1 h.

(c) The rate of a first order reaction is 0.04 mol L^{-1}s^{-1} at 10 minutes and 0.03 mol L^{-1} s^{-1} at 20 minutes after initiation. Find the half life of the reaction.

26. (a) Ignoring the water lost by evaporation, some water has still to be added periodically into the battery used in an invertor or car. Why? Why this is not required in the maintenance free batteries?

(b) Why electrolysis of NaBr and NaI gives Br_2 and I_2 respectively while that of NaF gives O_2 instead of F_2?

(c) Two half cell reactions of an electrochemical cell are given below :

$$MnO^-_{4(aq)} + 8H^+_{(aq)} + 5e^- \longrightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)},\ E° = +1.51\ V$$

$$Sn^{4+}_{(aq)} + 2e^- \longrightarrow Sn^{2+}_{(aq)},\ E° = +0.15\ V$$

Construct the redox reaction from the two half cell reactions and predict if this reaction favours formation of reactants or products shown in the equation.

OR

Answer the following :

(a) Suggest a way to determine Λ°_m value of water.

(b) The molar conductivity of 0.025 mol L^{-1} methanoic acid is 46.1 S cm^2 mol^{-1}. Calculate its degree of dissociation and dissociation constant. Given

$\lambda^\circ_{(H^+)} = 349.6$ S cm^2 mol^{-1} and

$\lambda^\circ_{(HCOO^-)} = 54.6$ S cm^2 mol^{-1}

27. Answer the following :

(a) Why silica and alumina gels are used for removing moisture and controlling humidity?

(b) On which factors adsorption of a solute from a solution depends?

(c) Define:

(i) Electrophoresis **(ii)** Coagulation

OR

(a) Give four examples of heterogeneous catalysis.

(b) What do you mean by activity and selectivity of catalysts?

(c) Explain the following terms :

(i) Dialysis **(ii)** Tyndall effect

SOLUTIONS

1. Because rate of reaction is affected by change in concentration not amount.

2. Electrolyte 'B' is stronger than 'A' because in strong electrolyte conductance is not much affected by dilution as these are already completely ionised. Therefore, Λ_m increases only 1.5 times due to decrease in interionic attraction. While in case of weak electrolyte on dilution number of constituent ions increases so conductance increases sharply.

3. Negatively charged colloidal particle : As_2S_3
Positively charged colloidal particle : $Fe(OH)_3$

4. $A + B \longrightarrow$ Product
Rate law, $r = k[A]^{1/2}[B]^2$

Order of reaction is sum of the powers of concentration terms,

$\therefore$ Order of reaction $= \frac{1}{2} + 2 = \frac{5}{2} = 2.5$

5. Higher the critical temperature of a gas, greater the ease of liquefaction. *i.e.*, greater the van der Waals' forces of attraction and hence greater the adsorption.

6. Equilibrium constant of a reaction is related to the E°_{cell} through the relationship,

$\Delta G^\circ = -nFE^\circ_{cell} = -2.303\,RT \log K$

So, $\log K = \dfrac{nFE^\circ_{cell}}{2.303 \times R \times T} = \dfrac{2 \times 96500 \times 0.46}{2.303 \times 8.31 \times 298} = 15.57$

$K = \text{antilog } 15.57 = 3.71 \times 10^{15}$

7. **(a)** Due to presence of incomplete *d*-subshell, transition elements have a large number of unpaired electrons *i.e.*, free valencies, hence, chemical adsorption occurs readily.

(b) Free valencies present on the surface of solid catalyst combine temporarily with reacting molecules causing a strain on the system, as a result, reactivity of reactants is increased.

8. **(a)** According to collision theory, apart from energy considerations, the colliding molecules should also have proper orientation for a reaction to occur.

Rate of reaction is directly proportional to the number of effective collisions.

(b) No, the molecularity can never be zero or a fractional number as it shows the number of reactants taking part in a reaction which can never be zero.

9. Normality of a solution is given by the number of equivalents per dm^3 (or per litre) of the solution. Therefore,

Concentration of the given solution = 0.12 equiv/dm^3

Conductivity of the solution, $(\kappa) = 0.024$ S cm^{-1}

(a) The equivalent conductivity is given by,

$$\Lambda_{eq} = \frac{1000\,\kappa}{N} = \frac{1000 \times 0.024}{0.12}\ \text{S cm}^2\ \text{equiv}^{-1}$$
$$= 200\ \text{S cm}^2\ \text{equiv}^{-1}$$

(b) For the given electrolyte $n = 1$

Then, $\Lambda_m = 1 \times \Lambda_{eq} = 1 \times 200$ S cm^2 mol^{-1}

$= 200$ S cm^2 mol^{-1}

10. **(a)** Rate of reaction $= \dfrac{-dp_{CH_3CHO}}{dt}$

$$= \frac{\text{Change in pressure}}{\text{Change in time}} = \frac{\text{atmosphere}}{\text{min}} = \text{atm min}^{-1}$$

(b) Unit of rate constant k can be obtained as follows.

$$k = \frac{\text{Reaction rate}}{(p_{CH_3CHO})^{3/2}} = \frac{\text{atm}\,.\,\text{min}^{-1}}{(\text{atm})^{3/2}} = \text{atm}^{-1/2}\ \text{min}^{-1}$$

OR

Let, initial conc. of the reactant $= a$

Final conc. of the reactant $= \dfrac{1}{16} \times a = \dfrac{a}{16}$

For a first order reaction,

$$k = \frac{2.303}{t} \log \frac{[A_0]}{[A_t]}$$

$$\therefore\ t = \frac{2.303}{k} \log \frac{a}{a/16} = \frac{2.303}{60\ \text{s}^{-1}} \log 16 = 0.046\ \text{s}$$

11. 5 mL of 1 M NaCl contains NaCl $= \dfrac{1}{1000} \times 5$ moles $= 5$ millimoles

Thus, 100 mL of As_2S_3 sol require NaCl for complete coagulation = 5 millimoles

$\therefore$ 1 L, *i.e.*, 1000 mL of the sol require NaCl for complete coagulation = 50 milimoles

$\therefore$ Thus, flocculation value of NaCl = 50

12. **(a)** This is because H^+ ions produced from ionization of water have lower discharge potential than Na^+ ions produced from ionization of NaCl or reduction potential of water is greater than that of sodium ions.

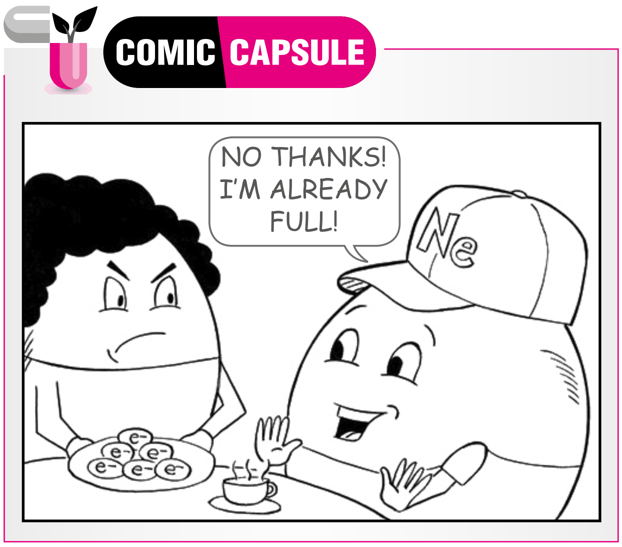
(b) The reactions at cathode for the deposit of Na and Al are

$Na^+ + e^- \longrightarrow Na$ and $Al^{3+} + 3e^- \longrightarrow Al$

Thus, 1 faraday deposits 1 mol of Na whereas 3 faradays are required for depositing one mol of Al.

13.

	$Cl_2O_7 \longrightarrow$	Cl_2 +	$\frac{7}{2}O_2$
Mole at $t = 0$	a	0	0
Mole at $t = 55$ sec	$(a - x)$	x	$7x/2$



(a) Since, pressure of Cl_2O_7 is given so,
$a \propto 0.062$

$$k = \frac{2.303}{t}\log_{10}\frac{a}{a-x} = \frac{2.303}{55}\log_{10}\frac{0.062}{0.044}$$

$k = 6.24 \times 10^{-3}\ \text{sec}^{-1}$

(b) At $t = 100$ sec, $(a - x) \propto p_t$

$$\therefore\ 6.24\times10^{-3} = \frac{2.303}{100}\log_{10}\frac{0.062}{p_t}$$

$$\log_{10}\frac{0.062}{P_t} = \frac{6.24\times10^{-1}}{2.303} = 0.270$$

$$\frac{0.062}{p_t} = 1.86$$

$\therefore\ p_t = 0.033$ atm

14. The cathodic reaction is $Au^{3+} + 3e^- \longrightarrow Au$

Therefore, equivalent mass of Au $= \dfrac{\text{Atomic mass}}{3}$

$$= \frac{197}{3} = 65.7$$

Number of equivalents of gold deposited $= \dfrac{1.20}{65.7} = 0.0183$

Thus, the number of faradays of electricity passed through the solution is equal to 0.0183.

(a) Since, 1 F of electricity would liberate 1 equivalent of O_2 gas, hence the number of equivalents of O_2 liberated during electrolysis is 0.0183.

For oxygen, equivalent mass $= \dfrac{\text{Molecular mass}}{4}$

Therefore, amount of oxygen liberated

$$= \frac{0.0183}{4}\text{ mol} = 0.00457\text{ mol}$$

(b) Number of coulombs of electricity passed
$= 96{,}500 \times 0.0183 = 1.76 \times 10^3$C

(c) $Q = I\,t$

Therefore, $t = \dfrac{Q}{I} = \dfrac{1.76\times10^3\ \text{C}}{0.5\ \text{A}} = 3.52\times10^3\ \text{s}$

15. (a) (i) Smaller the size of the particles of the adsorbent, greater is the surface area, greater is the adsorption.

(ii) At constant temperature, adsorption first increases with increase of pressure and then attains equilibrium at high pressures.

(iii) In physical adsorption, it decreases with the increase of temperature but in chemisorption, first it increases and then decreases.

(b) (i) Multimolecular, because sulphur molecules associate together to form colloidal sol.

(ii) Macromolecular, because protein molecules present in the white of the egg are macromolecules soluble in water.

(iii) Associated, because at higher concentrations (above CMC) $RCOO^-$ ions associate together to form micelles.

16. (a) The cell reaction may be split into two half reactions as :

$Zn \longrightarrow Zn^{2+} + 2e^-$ (Oxidation half reaction)

$2Ag^+ + 2e^- \longrightarrow 2Ag$ (Reduction half reaction)

$E^\circ_{cell} = E^\circ_{oxidation} + E^\circ_{reduction}$
$= +\,0.76 + 0.80$ volt $= 1.56$ volts

(b) Here, $C_1 = 10^{-6}$ M, $C_2 = ?$

For the given concentration cell,

$$E_{cell} = \frac{0.0591}{n}\log\frac{C_2}{C_1}\ ;\ 0.118 = \frac{0.0591}{1}\log\frac{C_2}{10^{-6}}$$

$$\text{or}\ \log\frac{C_2}{10^{-6}} = 2\ \text{ or }\ \frac{C_2}{10^{-6}} = \text{Antilog } 2 = 10^2$$

$\therefore\ C_2 = 10^2 \times 10^{-6} = 10^{-4}$ M

17. (a) : The rate of reaction at a particular instant (time) is called instantaneous rate of reaction.

$$r_{ins} = \frac{dx}{dt}$$

dx = small change in concentration
dt = small time interval

(b) Let the concentration of the reactant $[A] = a$

Order of reaction = 2 so that,

Rate of reaction $= k\,[A]^2$ ...(1)
$= ka^2$

(i) Given that concentration of the reactant is doubled so, that $[A] = 2a$,

Putting the value in equation (1) we get

New rate of reaction, $R_1 = k(2a)^2 = 4ka^2$

Hence, rate of reaction will increase to 4 times.

(ii) Given that concentration of the reactant is reduced to half

So that, $[A] = (1/2)a$

Putting the value in equation (1), we get

New rate of reaction $R_2 = k((1/2)a)^2$
$= (1/4)ka^2$

Hence, rate of reaction will reduce to 1/4.

18. (a) The catalytic reaction which depends upon pore structure of catalyst and the size of the reactant and product molecules is known as shape selective catalysis.

(b) The high porosity of zeolites is due to the presence of the network honey comb like structures of interconnected channels and cavities of molecular

dimensions. These pores (voids) have the volume even more than 50% of the total volume which is occupied by '*m*' molecules of water in the unit cell. These vacant spaces are thus able to absorb (or lose) water molecules readily. The ions or molecules of the right size can be absorbed by them and thus zeolites act as molecular sieves or shape selective catalyst.

(c) Enzymes are nitrogeneous, proteineous complex organic compounds while other catalysts are; in general, metals and inorganic compounds.

OR

(a) Since the adsorption process is exothermic, the physical adsorption occurs readily at low temperature and decreases with increasing temperature (Le Chatelier's principle).

(b) Few impurities which are soluble in water and are adsorbed on the surface of the precipitate are removed by washing them with water.

(c) Adsorption of an adsorbate increases with increasing surface area of adsorbent. Since surface area of a finely divided substance is larger than any other form of adsorbent, hence it is more effective adsorbent.

19. $\Delta G^\circ = -nFE^\circ_{cell}$

$$E^\circ_{cell} = \frac{\Delta G^\circ}{-nF} = \frac{-43600}{-2\times 96500} = 0.226\text{ V}$$

$$2AgCl_{(s)} + H_{2(g)}\ (1\text{ atm}) \longrightarrow 2Ag_{(s)} + 2H^+(0.1\text{ M}) + 2Cl^-(0.1\text{ M})$$

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{n}\log\frac{[\text{Product}]}{[\text{Reactant}]}$$

$$= 0.226 - \frac{0.0591}{2}\log\frac{(0.1)^2}{(1)} = 0.226 - \frac{0.0591}{2}\log(10^{-2})$$

$$= 0.226 - \frac{0.0591}{2}(-2) = 0.226 + 0.0591 = 0.2851\text{ V}$$

20. (a) The minimum extra energy which must be supplied to the reactants to enable them to cross over the potential energy barrier between reactants and products is called activation energy. It is denoted by E_a.

$$E_a = E_T - E_R$$

(b) $T_1 = 295$ K, $k_1 = k$ (say)

$T_2 = 305$ K, $k_2 = 2k$, $E_a = ?$

Using Arrhenius equation

$$\log\frac{k_2}{k_1} = \frac{E_a}{2.303\,R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$$

$$\log\frac{2k}{k} = \frac{E_a}{2.303\times 8.314}\times\frac{305-295}{295\times 305}$$

$$E_a = \frac{2.303\times 8.314\times 295\times 305\times \log 2}{10}$$

$$= \frac{2.303\times 8.314\times 295\times 305\times 0.3010}{10}$$

$= 51855.2$ J mol^{-1} = 51.855 kJ mol^{-1}

21. Preparation of colloids :

(a) Chemical methods : In this method colloidal sols are prepared by oxidation, reduction, hydrolysis and double decomposition.

(i) $As_2O_3 + 3H_2S \xrightarrow{\text{Double decomposition}} \underset{\text{(Sol)}}{As_2S_3} + 3H_2O$

(ii) $SO_2 + 2H_2S \xrightarrow{\text{Oxidation}} \underset{\text{(Sol)}}{3S} + 2H_2O$

(iii) $2AuCl_3 + 3HCHO + 3H_2O \xrightarrow{\text{Reduction}} \underset{\text{(Sol)}}{2Au} + 3HCOOH + 6HCl$

(iv) $FeCl_3 + 3H_2O \xrightarrow{\text{Hydrolysis}} \underset{\text{(Sol)}}{Fe(OH)_3} + 3HCl$

(b) Bredig's arc method : In this method, electric arc is struck between electrodes of the metal immersed in the dispersion medium. The intense heat produced vaporises the metal, which then condense to form particles of colloidal size. This method involve both dispersion and condensation and usually used to prepare metal sols like Pt, Au, Cu, Ag etc.

(c) Peptization : It is the process of converting precipitate into colloidal solution by shaking it with dispersion medium in the presence of a small amount of electrolyte. Only freshly prepared precipitates may be peptized.

22. Volume of $KMnO_4$ solution used ∝ amount of H_2O_2 present. Hence, if the given reaction is of the first order, it must obey the equation :

$$k = \frac{2.303}{t}\log\frac{a}{a-x} = \frac{2.303}{t}\log\frac{V_0}{V_t}$$

In the present case, $V_0 = 46.1$ cm^3

The value of k at each instant can be calculated as follows:

t(min)	V_t	$k = \frac{2.303}{t}\log\frac{V_0}{V_t}$
10	29.8	$k = \frac{2.303}{10\text{ min}}\log\frac{46.1}{29.8} = 0.0436\text{ min}^{-1}$
20	19.3	$k = \frac{2.303}{20\text{ min}}\log\frac{46.1}{19.3} = 0.0435\text{ min}^{-1}$

Thus, the value of k comes out to be nearly constant. Hence, it is a reaction of the first order.

23. $\kappa = 1.29 \times 10^{-2}\ \text{ohm}^{-1}\ \text{cm}^{-1}$

$\kappa = \frac{1}{R} \times$ Cell constant

$\Rightarrow$ Cell constant $= \kappa \times R$

$= 1.29\ \text{S m}^{-1} \times 85 = 109.65\ \text{m}^{-1}$

For second solution,

$$\kappa = \frac{1}{R} \times \text{Cell constant} = \frac{1}{96\ \Omega} \times 109.65\ \text{m}^{-1}$$

$$= 1.142\ \Omega^{-1}\text{m}^{-1}$$

$$\Lambda_m = \frac{\kappa \times 1000}{M} = \frac{1.142\ \Omega^{-1}\text{m}^{-1} \times 1000\ \text{cm}^3}{0.052}$$

$$\Lambda_m = \frac{1.142\ \Omega^{-1}\text{cm}^{-1} \times 10^{-2} \times 1000\ \text{cm}^3}{0.052\ \text{mol}}$$

$$= 219.61\ \text{S cm}^2\ \text{mol}^{-1}$$

24. (a) Ions (either +ve or −ve) of peptising agent (electrolyte) are adsorbed on the particles of the precipitate. They repel and hit each other breaking the particles of the precipitate into colloidal size.

(b) It neutralizes the charge on the carbon particles which get precipitated and thus gases entering into chimney are free from carbon particles.

(c) This is done because gold particles have large surface rea and easily assimilated into blood which is colloidal.

25. (i) The rate of disappearance of $B_2 = -\frac{d[B_2]}{dt}$

or $r = k[A]^m[B_2]^n$

then $1.8 \times 10^{-3} = k[0.015]^m\ [0.15]^n$ ...(i)

$1.085 \times 10^{-2} = k[0.090]^m\ [0.15]^n$ ...(ii)

$5.4 \times 10^{-3} = k[0.015]^m\ [0.45]^n$ ...(iii)

From eqns. (i) and (ii),

$$\frac{1.8 \times 10^{-3}}{1.085 \times 10^{-2}} = \left[\frac{0.015}{0.090}\right]^m \Rightarrow m = 1$$

From eqns. (i) and (iii),

$$\frac{1.8 \times 10^{-3}}{5.4 \times 10^{-3}} = \left[\frac{0.15}{0.45}\right]^n \Rightarrow n = 1$$

Order of reaction = 1 + 1 = 2

(ii) Rate of disappearance of $B_2 = k[A]^1[B_2]^1$

$\therefore\ 1.8 \times 10^{-3} = k[0.015]^1[0.15]^1$

$k = 0.8\ \text{L mol}^{-1}\ \text{sec}^{-1}$

(iii) Now, $\frac{1}{2}\frac{d[AB]}{dt} = -\frac{d[B_2]}{dt}$

$$\frac{d[AB]}{dt} = 2 \times \left[-\frac{d[B_2]}{dt}\right] = 2 \times k[A]^1\ [B_2]^1$$

or $\frac{d[AB]}{dt} = 2 \times 0.8 \times (0.02)^1 (0.04)^1 = 1.28 \times 10^{-3}$

OR

(a) For a first order reaction,

$$t = \frac{2.303}{k} \log \frac{a}{a-x}$$

Here, initial concentration, a = 10 g and concentration left after time t sec = 2.5 g *i.e.*, $(a - x)$ = 2.5 g, specific reaction constant $k = 10^{-3}\ \text{sec}^{-1}$

Time required for the reactant to reduce to 2.5 g

$$= \frac{2.303}{10^{-3}} \times \log \frac{10}{2.5}$$

$$= \frac{2.303}{10^{-3}} \times \log 4 = \frac{2.303}{10^{-3}} \times 0.6021 = 1386.6\ \text{s}$$

(b) Rate constant in min^{-1} shows that it is a reaction of 1^{st} order.

$$\therefore\quad k = \frac{2.303}{t} \log \frac{[A]_0}{[A]_t} = \frac{2.303}{60\ \text{min}} \log \frac{1}{[A]_t}$$

$$= 4.5 \times 10^{-3}\ \text{min}^{-1}$$

or $\log[A]_t = -0.1172$

$\therefore\quad [A]_t = 0.7635\ \text{mol L}^{-1}$

This is the concentration after 1 hr.

Rate of reaction after 1h $= k[A]_t$

$= 4.5 \times 10^{-3} \times 0.7635\ \text{mol L}^{-1}\ \text{min}^{-1}$

$= 3.44 \times 10^{-3}\ \text{mol L}^{-1}\ \text{min}^{-1}$

(c) For a first order reaction, $A \longrightarrow$ Products, for concentration of the reactant at two different times,

$$k = \frac{2.303}{t_2 - t_1} \log \frac{[A]_1}{[A]_2}$$

But as rate $= k[A]$, therefore, $\frac{(\text{rate})_1}{(\text{rate})_2} = \frac{[A]_1}{[A]_2}$

Hence, $k = \frac{2.303}{t_2 - t_1} \log \frac{(\text{rate})_1}{(\text{rate})_2}$

$$= \frac{2.303}{(20-10)\ \text{min}} \log \frac{0.04}{0.03} = 2.88 \times 10^{-2}\ \text{min}^{-1}$$

$$\therefore\quad t_{1/2} = \frac{0.693}{k} = \frac{0.693}{2.88 \times 10^{-2}\ \text{min}^{-1}}$$

$$= 24.06\ \text{min} = 1443.6\ \text{s}$$

26. (a) During discharge, electrolysis of water also takes place. Hence, some water is lost due to electrolysis of water into H_2 and O_2. Hence, water has to be added

periodically into the acid of the battery to have desired concentration. Now a days, in the maintenance free batteries, no water needs to be added as they use electrodes of Ca/Pb alloy which prevents electrolysis of water.

(b) Br^- and I^- ions have higher oxidation potentials than water. Hence, they are more easily oxidized. But F^- ions have lower oxidation potential than H_2O. So, H_2O is easily oxidized to give O_2 gas.

(c) $MnO^-_{4(aq)} + 8H^+_{(aq)} + 5e^- \rightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}] \times 2$ ...(i)

$Sn^{2+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + 2e^-] \times 5$ ...(ii)

$2MnO_4^- + 16H^+ + 5Sn^{2+} \longrightarrow 2Mn^{2+} + 5Sn^{4+} + 8H_2O$

Oxidation potential of 2nd reaction = –0.15 V (as the given value is reduction potential).

$E^\circ_{cell} = 1.51 + (-0.15)\text{ V} = 1.36\text{ V}$.

Hence, reaction will favour formation of products as represented above.

OR

(a) Water is a weak electrolyte, hence Λ°_m value of water is determined using Kohlrausch law.

$\Lambda^\circ_m(H_2O) \longrightarrow \lambda^\circ_m(H^+) + \lambda^\circ_m(OH^-)$

It can be determined by knowing the Λ°_m of three electrolytes HCl, NaOH and NaCl.

Applying Kohlrausch law,

$\Lambda^\circ_m(H_2O) \longrightarrow \Lambda^\circ_m(HCl) + \Lambda^\circ_m(NaOH) - \Lambda^\circ_m(NaCl)$

(b) Given, $\lambda^\circ_m(H^+) = 349.6\text{ S cm}^2\text{ mol}^{-1}$

$\lambda^\circ_m(HCOO^-) = 54.6\text{ S cm}^2\text{ mol}^{-1}$

$\Lambda^c_m(HCOOH) = 46.1\text{ S cm}^2\text{ mol}^{-1}$

$\alpha = ?$

From Kohlrausch law,

$\Lambda^\circ_m(HCOOH) = \lambda^\circ_m(H^+) + \lambda^\circ_m(HCOO^-)$

or $\Lambda^\circ_m(HCOOH) = 349.6\text{ S cm mol}^{-1} + 54.6\text{ S cm}^2\text{ mol}^{-1}$

$= 404.2\text{ S cm}^2\text{ mol}^{-1}$

Using formula

$$\alpha = \frac{\Lambda^c_m}{\Lambda^\circ_m} = \frac{46.1\text{ S cm}^2\text{ mol}^{-1}}{404.2\text{ S cm}^2\text{ mol}^{-1}} = 0.114$$

$$\text{Again, } K_a = \frac{\alpha^2 C}{1-\alpha}$$

$$= \frac{(0.114)^2 \times 0.025\text{ mol L}^{-1}}{1-0.114} = 3.67 \times 10^{-4}$$

27. (a) Alumina and silica are good adsorbents. They can adsorb even small amount of moisture present in atmosphere.

(b) Following factors affect adsorption of solute from solution:

(i) The extent of adsorption decreases with an increase in temperature.

(ii) It increases with an increase of surface area of the adsorbent.

(iii) It also depends on the increase in the concentration of the solute in the solution.

(iv) It also depends on nature of adsorbent and adsorbate.

(c) (i) The movement of colloidal particles under an applied electrode potential is called electrophoresis.

(ii) The process of settling of colloidal particles under the effect of gravity is called coagulation.

OR

(a) Examples of heterogenous catalysis:

Oxidation of sulphur dioxide to sulphur trioxide.

$2SO_{2(g)} + O_{2(g)} \xrightarrow{Pt_{(s)}} 2SO_{3(g)}$

Formation of ammonia by Haber's process.

$N_{2(g)} + 3H_{2(g)} \xrightarrow{Fe_{(s)}} 2NH_{3(g)}$

Oxidation of NH_3 into nitric oxide.

$4NH_{3(g)} + 5O_{2(g)} \xrightarrow{Pt_{(s)}} 4NO_{(g)} + 6H_2O_{(g)}$

Hydrogenation of vegetable oils to vegetable ghee.

$\text{Veg. oil}_{(l)} + H_{2(g)} \xrightarrow{Ni_{(s)}} \text{Veg. ghee}_{(s)}$

(b) Activity means capacity of a catalyst to increase the rate of the reaction. It depends upon the strength of chemisorption to a large extent.

Selectivity of a catalyst is its ability to direct a reaction to yield a particular product.

(c) (i) Dialysis is a process of removing a dissolved substance from a colloidal solution by means of diffusion through a semipermeable membrane.

(ii) Scattering of light by the charged particles is called Tyndall effect.

BRUSH UP YOUR CONCEPTS

Class XII

This specially designed column will help you to brush up your concepts by practicing questions. You can mail us your queries and doubts related to this topic at editor@mtg.com. The queries will be entertained by the author.

SOLID STATE

Crystallography

- A solid having sharp m.pt., anisotropy, sharp edges, clean faces and long range definite pattern of packing of particles is called a crystalline solid or true solid. Other solids are isotropic, have crystalline structure at some places and are called psuedo solids or amorphous solids.
- Crystalline solids are classified into four classes, based on intermolecular forces :
  (a) Network covalent solids have extremely high m.pt. *e.g.*, SiC, SiO_2, diamond, graphite, etc. These are electrical insulators except graphite.
  (b) Ionic solids have coulombic forces in cations and anions, very high m.pt. *e.g.*, NaCl
  (c) Metallic solids have attraction between electron cloud (ocean) and kernels. Their m.pt. range between quite low to very high. W (tungsten) has highest m.pt. among metals and Hg is liquid.
  (d) Molecular solids are all insulators of electricity. Hydrogen bonded molecular solids (*e.g.*, ice) are hard while polar (*e.g.*, SO_2) and non-polar (*e.g.*, CCl_4, CO_2, etc.) are soft.
- Crystal lattice is the three dimensional representation of a crystal showing constituent particles as points. The smallest portion of a crystal lattice whose multiplicity gives the entire lattice, is called a unit cell. Based on the six parameters, three intercepts on three axes, *viz.*, *a*, *b* and *c* and three interfacial angles α, β and γ, unit cells are classified in seven crystal systems. Based on locations of particles in these crystal systems we have 14 Bravais lattices. A cubic system [$\alpha = \beta = \gamma = 90°$, $a = b = c$] has primitive, body centred and face centred Bravais lattices.
  A hexagonal crystal system has $\alpha = \beta = 90°$, $\gamma = 120°$ and $a = b \neq c$.
- Based on locations of particles in unit cell, a cubic lattice can be simple (*sc*), body centred (*bcc*) or face centred cubic close packing (*fcc* or *ccp*). The percentage of occupied space (packing efficiency) (P.E.) and packing fractions (P.F.) are given below :

	sc	*bcc*	*fcc*
P.F.	0.524 or $\frac{\pi}{6}$	0.68 or $\frac{\sqrt{3}}{8}\pi$	0.74 or $\frac{\pi}{3\sqrt{2}}$
P.E.	52.4%	68%	74%

- With usual meanings of letters, some formulae are :
  (a) $d(\text{g cm}^{-3}) = \dfrac{ZM}{a^3 N_A}$
  (b) Number of unit cells in *m* gram of element $= \dfrac{mN_A}{ZM}$, also, $\dfrac{m}{da^3}$
  (c) Number of atoms of element in *m* gram $= \dfrac{mN_A}{M}$, also $\dfrac{mZ}{d\,a^3}$
  (d) For elements : *Z* for sc = 1 ; *Z* for *bcc* = 2; *Z* for *fcc* = 4
- A triangular void formed by three spheres (particles) covered by fourth one becomes a tetrahedral void. Two triangular voids with opposite setting (from two 2D *hcp* layers) forms an octahedral void.
  If *n* particles are making a packing we get 2*n* tetrahedral voids (two T.V. per atom) and *n* octahedral voids (one O.V. per atom).

By **R.C. Grover**, having 45+ years of experience in teaching chemistry.

In *fcc* cubic close packing there are eight tetrahedral voids (one in $\frac{1}{8}$ part) and four octahedral voids (one at centre + $\frac{1}{4}$ of 12 on edges).

MULTIPLE CHOICE QUESTIONS

1. The correct decreasing order of packing efficiency of cubic lattices is
(a) *bcc* > *fcc* > *sc* (b) *sc* > *fcc* > *bcc*
(c) *fcc* > *sc* > *bcc* (d) *fcc* > *bcc* > *sc*

2. The distance between two tetrahedral voids in an *fcc* can be (a is edge of cube)
(a) $\frac{a}{2}$ (b) $\frac{a}{\sqrt{2}}$
(c) $\sqrt{3}\cdot\frac{a}{\sqrt{2}}$ (d) all of these.

3. The distance between two octahedral voids in an *fcc* can be (a is edge of cube)
(a) $\frac{a}{\sqrt{2}}$ (b) a
(c) $\sqrt{3}, \frac{a}{\sqrt{2}}$ (d) both (a) and (b).

4. The number of C-atoms per unit cell of diamond is
(a) 8 (b) 2
(c) 4 (d) 1

5. Total number of voids in the packing made by 0.01 mole of atoms is
(a) 3 (b) 1.806×10^{22}
(c) 6.02×10^{21} (d) 6.02×10^{23}

6. The distances between body centre to corner and to face centre in a cube, respectively, are (a is edge of cube)
(a) $\frac{a}{2}, \frac{a}{2}$ (b) $\frac{\sqrt{3}\cdot a}{2}, \frac{\sqrt{3}\cdot a}{2}$
(c) $\frac{a}{2}, \frac{\sqrt{3}\cdot a}{2}$ (d) $\frac{\sqrt{3}\cdot a}{2}, \frac{a}{2}$

7. Edge length of a cube is 3000 nm, the body diagonal is
(a) 1.965×10^{-3} cm (b) 5.196×10^{-4} cm
(c) 9.165×10^{-5} cm (d) 6.519×10^{-4} cm

8. Percentage of unoccupied space in *sc*, *bcc* and *fcc* respectively are
(a) 54.2%, 68%, 74% (b) 68%, 54.2%, 74%
(c) 45.8%, 32%, 26% (d) 26%, 45.8%, 32%

9. Fe and Au crystallise as *bcc* and *fcc* respectively. The total number of their atoms in unit cells in respective order is
(a) 2, 4 (b) 4, 2
(c) 2, 6 (d) 1, 6

10. Two *fcc* systems of elements A and B are fused in each other. What is the total number of locations of particles and formula of the compound?
(a) 6, A_2B_3 (b) 12, AB
(c) 27, AB (d) 28, A_3B_2

11. In an *fcc* packing of element A, some atoms from their locations are replaced by B and C. Atoms of element B occupy the alternate faces while atoms of C occupy alternate edges. No location of *fcc* packing is now vacant. The formula of the compound is
(a) A_4B_2C (b) A_2BC
(c) $A_4B_3C_2$ (d) A_3B_2C

12. In the *fcc* packing of element X, atoms on one face axis are missing and have been occupied by atoms of element Y. The formula of the compound is
(a) XY_3 (b) XY
(c) X_3Y (d) X_2Y

13. Atoms of element A form *fcc*, atoms of element B are located in one-third of tetrahedral voids while C are located in half of octahedral voids. The formula of the compound is
(a) $A_3B_4C_6$ (b) $A_4B_3C_6$
(c) $A_6B_4C_3$ (d) $A_6B_3C_4$

14. What is the radius of atom having at. wt. 30 forming cubic unit cell of edge length 400 pm? ($d = 3.115$ g cm^{-3})
(a) 100 pm (b) 141.4 pm
(c) 242.6 pm (d) 101.1 pm

15. The number of atoms of element in 135 g, forming *bcc* lattice of edge length 300 pm and density 3 g per cm^3 is
(a) 1×10^{25} (b) 2.22×10^{25}
(c) 3.33×10^{24} (d) 4.44×10^{23}

Quotable Quote

Science means constantly walking a tightrope between blind faith and curiosity; between expertise and creativity; between bias and openness; between experience and epiphany; between ambition and passion and between arrogance and conviction – in short between an old today and a new tomorrow.

Heinrich Rohrer

16. Under different conditions an element crystallises in *bcc* and *fcc* systems of edge lengths 100 pm and 200 pm respectively. The ratio of their densities is
(a) 1 : 2 (b) 2 : 1
(c) 1 : 4 (d) 4 : 1

17. An element *A* crystallises in two different types of cubic unit cells (*x* and *y*) of edge lengths 300 and 400 pm respectively. If their densities are in the ratio 1.185, what are the types of packing of *x* and *y* respectively?
(a) *fcc*, *sc* (b) *bcc*, *sc*
(c) *fcc*, *bcc* (d) *bcc*, *fcc*

18. An element occupies *bcc* structure with cell edge length of 300 pm. The density of the element is 7 g cm^{-3}. The number of unit cells in 200 g of element is
(a) 6.022×10^{23} (b) 6.022×10^{24}
(c) 1.058×10^{24} (d) 1.058×10^{26}

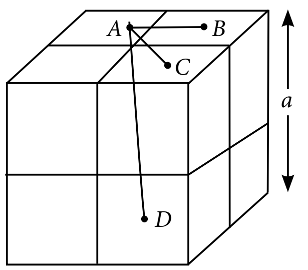
19. An element is found in *fcc* of unit cell edge length of 300 pm. The radius of the atom is
(a) 150 pm (b) 106 pm
(c) 160 pm (d) 165 pm

20. An element crystallises in *bcc* and *fcc* with exactly same interatomic distances. The ratio of their densities will be
(a) 0.92 : 1.00 (b) 0.29 : 1.00
(c) 1.00 : 0.92 (d) 1.00 : 0.29

SOLUTIONS

1. **(d) :** Packing efficiencies are : *fcc* = 74%, *bcc* = 68%, *sc* = 52.4%

2. **(d) :** Observe *A*, *B*, *C* and *D* inside the cube



(a) In two nearest cases = $AB = \frac{a}{2}$

(b) Next two cases = $\frac{1}{2}$ × face diagonal

$$= AC = \frac{\sqrt{2}\,a}{2} = \frac{a}{\sqrt{2}}$$

(c) Next two cases = $\frac{1}{2}$ × body diagonal

$$= AD = \frac{\sqrt{3}\cdot a}{2}$$

3. **(d) :** Octahedral voids are at edge centres and body centre.
Distance (i) Edge to nearest edge (centres) = *a*
(ii) Body centre to edge centre = $\frac{\sqrt{2}\cdot a}{2} = \frac{a}{\sqrt{2}}$

4. **(a) :** In diamond, C-atoms are at
(i) all corners of cube = 1
(ii) all face centres = 3
(iii) alternate tetrahedral = 4
Total C-atoms per unit cell = 8

5. **(b) :** Number of voids per atom = 2-TV + 1-OV = 3
Number of voids for 0.01 mole
$= 0.01 \times 6.02 \times 10^{23} \times 3 = 1.806 \times 10^{22}$

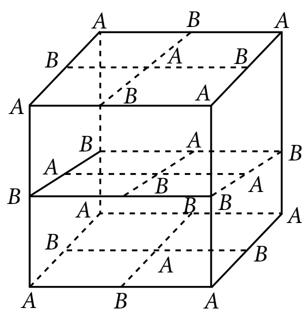
6. **(d) :** Distance from body centre to corner
$= \frac{1}{2}$ × body diagonal $= \frac{1}{2} \times \sqrt{3}\cdot a$
Distance from body centre to face centre
$= \frac{1}{2} \times \text{edge} = \frac{a}{2}$

7. **(b) :** Body diagonal = $\sqrt{3}\cdot a$
$= 1.732 \times 3000 \times 10^{-9} \times 10^{2}$ cm $= 5.196 \times 10^{-4}$ cm

8. **(c) :** Unoccupied spaces :
sc = 100 – 54.2 = 45.8%
bcc = 100 – 68 = 32%
fcc = 100 – 74 = 26%

9. **(a) :** Fe, *bcc*, 1 atom from corners and one from body centre.
Au, *fcc*, 1 atom from corners and 3 from 6 face centres.

10. **(c) :**



'*A*' atoms = 8 corners + 6 face centres = 14 locations
= 1 + 3 = 4
'*B*' atoms = 12 edge centres + 1 body centre
= 13 locations = 3 + 1 = 4
Total locations = 14 + 13 = 27

11. (b) : B at alternate faces (2 opposite faces) = 1
C at alternate edges (4 edges) = 1
A = 2
Formula = A_2BC

12. (c) : Y atoms are present at one face axis, *i.e.*, two opposite faces = 1
X forms *fcc*, 4 – 1 = 3
Formula = X_3Y

13. (c) : A, *fcc* = 4 atoms

$$B, \frac{1}{3} \text{ of TV} = \frac{1}{3} \times 8$$

$$C, \frac{1}{2} \text{ of OV} = \frac{1}{2} \times 4 = 2$$

$$A : B : C = 4 : \frac{8}{3} : 2 = 6 : 4 : 3$$

Formula = $A_6B_4C_3$

14. (b) : $Z = \dfrac{d N_A a^3}{M}$

$$= \frac{3.115 \times 6.02 \times 10^{23} \times (400)^3 \times 10^{-30}}{30}$$

= 4 ⇒ *fcc* packing
In *fcc*, $4r = \sqrt{2} \cdot a$

$$r = \frac{1.414}{4} \times 400 = 141.4 \text{ pm}$$

15. (c) : $d = \dfrac{ZM}{a^3 N_A}$ ⇒ No. of atoms = $\dfrac{Z \times \text{mass}}{a^3 \times d}$

$$= \frac{2 \times 135 \times 10^{30}}{(300)^3 \times 3} = 3.33 \times 10^{24}$$

16. (d) :

$$\frac{d_{bcc}}{d_{fcc}} = \frac{\left(\dfrac{ZM}{a^3 N_A}\right)_{bcc}}{\left(\dfrac{ZM}{a^3 N_A}\right)_{fcc}} = \frac{\left[\dfrac{2}{(100)^3}\right]}{\left[\dfrac{4}{(200)^3}\right]} = \frac{2}{4} \times \frac{2^3}{1^3} = 4 : 1$$

17. (d) :

$$\frac{d_1}{d_2} = \frac{\left(\dfrac{ZM}{a^3 N_A}\right)_x}{\left(\dfrac{ZM}{a^3 N_A}\right)_y}$$

$$1.185 = \frac{Z_x}{Z_y} \times \frac{4^3}{3^3}$$

$$\frac{Z_x}{Z_y} = \frac{1.185 \times 27}{64} = \frac{31.995}{64} = \frac{1}{2} \text{ or } \frac{2}{4}$$

18. (c) : Number of unit cells = $\dfrac{m}{d} \times \dfrac{1}{a^3}$

$$= \frac{200}{7} \times \frac{10^{30}}{(300)^3} = 1.058 \times 10^{24}$$

19. (b) : $4r = \sqrt{2} \cdot a$

$$r = \frac{\sqrt{2}}{4} \times 300 \text{ pm} = \frac{1.414 \times 300}{4} \text{ pm} = 106.05 \text{ pm}$$

20. (a) :

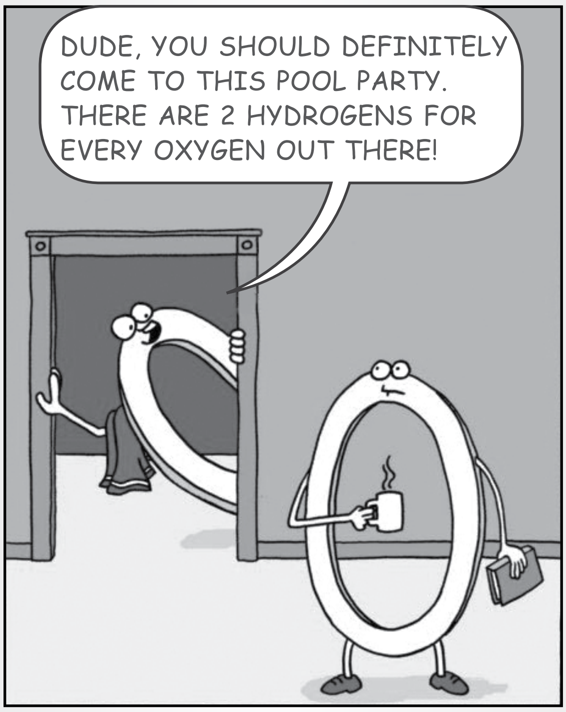
$$\frac{d_{bcc}}{d_{fcc}} = \frac{\left(\dfrac{ZM}{a^3 N_A}\right)_{bcc}}{\left(\dfrac{ZM}{a^3 N_A}\right)_{fcc}} = \frac{\left(\dfrac{2}{a^3}\right)_{bcc}}{\left(\dfrac{4}{a^3}\right)_{fcc}} = \frac{2}{4} \times \left(\frac{a_{fcc}}{a_{bcc}}\right)^3$$

For equal inter-atomic distances :
$(4r)_{bcc} = (4r)_{fcc}$

$$\sqrt{3} \cdot a_{bcc} = \sqrt{2} \cdot a_{fcc}$$

$$\frac{a_{fcc}}{a_{bcc}} = \frac{\sqrt{3}}{\sqrt{2}} \Rightarrow \frac{d_{bcc}}{d_{fcc}} = \frac{2}{4} \times \left(\frac{\sqrt{3}}{\sqrt{2}}\right)^3 = \frac{0.92}{1}$$

COMIC CAPSULE



Class XII

MONTHLY TUNE UP!

PRACTICE PROBLEMS

These practice problems enable you to self analyse your extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Performance analysis table given at the end will help you to check your readiness.

- The Solid State
- Solutions

Total Marks : 120 **Time Taken : 60 Min.**

NEET / AIIMS

Only One Option Correct Type

1. 1.00 g of a non-electrolyte solute (molar mass 250 g mol^{-1}) was dissolved in 51.2 g of benzene. If the freezing point depression constant, K_f , of benzene is 5.12 K kg mol^{-1}, the freezing point of benzene will be lowered by

(a) 0.3 K (b) 0.5 K
(c) 0.2 K (d) 0.4 K

2. Two beakers *A* and *B* are present in a closed vessel. Beaker *A* contains 152.4 g aqueous solution of urea, containing 12 g of urea. Beaker *B* contains 196.2 g glucose solution, containing 18 g of glucose. Both solutions are allowed to attain the equilibrium. The weight percentage of glucose in its solution at equilibrium is

(a) 6.71 (b) 14.49
(c) 16.94 (d) 20

3. An element crystallises in *fcc* lattice and edge length of unit cell is 400 pm. If density of unit cell is 11.2 g cm^{-1}, then atomic mass of the element is

(a) 215.6 (b) 431.2
(c) 107.8 (d) 98.6

4. Total number of tetrahedral and octahedral voids in 0.5 mol of a compound forming *hcp* structure are

(a) 6.022×10^{23} (b) 3.011×10^{23}
(c) 9.033×10^{23} (d) 4.516×10^{23}

5. The density of an ionic compound (Mol. wt. = 58.5) is 2.165 g cm^{-3} and the edge length of unit cell is 562 pm. The closest distance between A^+ and B^- and Z_{eff} of unit cell is

(a) 281 pm, 4 (b) 562 pm, 2
(c) 562 pm, 4 (d) 281 pm, 2

6. Consider the following solutions :

I. 1 M sucrose II. 1 M KCl
III. 1 M benzoic acid in benzene
IV. 1 M $(NH_4)_3PO_4$

Which of the following is not true?

(a) II is hypotonic of I.
(b) III is hypotonic of I, II, and IV.
(c) I, II, and III are hypotonic of IV.
(d) IV is hypertonic of I, II, and III.

7. An aqueous solution of an acid is so weak that it can be assumed to be practically un-ionised when boiled at 100.4°C. 25 mL of this solution was neutralised by 38.5 mL of 1 N solution of NaOH. What is the basicity of acid if K_b for water is 0.52 K mol^{-1} kg?

(a) 1 (b) 2
(c) 3 (d) 4

8. Percentage of free space in cubic close packed structure and in body-centred packed structure are respectively

(a) 48% and 26% (b) 30% and 26%
(c) 26% and 32% (d) 32% and 48%

9. An element has a body-centred cubic (*bcc*) structure with a cell edge of 288 pm. The density of the element is 7.2 g/cm^3. How many atoms are present in 208 g of the element?
(a) 6.02×10^{24} (b) 12.09×10^{23}
(c) 24.16×10^{23} (d) 29.88×10^{24}

10. 100 cc of 1.5% solution of urea is found to have an osmotic pressure of 6.0 atm and 100 cc of 3.42% solution of cane sugar is found to have an osmotic pressure of 2.4 atm. If the two solutions are mixed, the osmotic pressure of the resulting solution will be
(a) 3.6 atm (b) 4.2 atm
(c) 2.1 atm (d) 8.4 atm

11. Which of the following solutions has minimum freezing point?
(a) 0.01 M NaCl (b) 0.005 M C_2H_5OH
(c) 0.005 M MgI_2 (d) 0.005 M $MgSO_4$

12. Which one of the following statements is false?
(a) The correct order of osmotic pressure for 0.01 M aqueous solution of each compound is $BaCl_2 > KCl > CH_3COOH >$ Sucrose
(b) Raoult's law states that the vapour pressure of a component over a solution is proportional to its mole fraction.
(c) Two sucrose solutions of same molality prepared in different solvents will have the same freezing point depression.
(d) None of these.

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** In sodium chloride crystal, Na^+ ions occupy octahedral voids while Cl^- ions have *ccp* arrangement.
Reason : The radius ratio of $Na^+ : Cl^-$ lies between 0.4 and 0.7.

14. **Assertion :** Zinc blende and wurtzite both have *fcc* arrangement of S^{2-} ions.
Reason : A unit cell of both has four formula units of ZnS.

15. **Assertion :** Camphor is usually used in molecular mass determination.
Reason : Camphor has low cryoscopic constant and therefore, causes greater depression in freezing point.

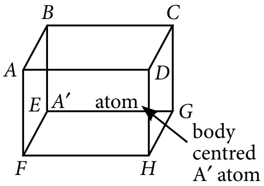
JEE MAIN / ADVANCED

Only One Option Correct Type

16. The vapour pressure of a pure liquid '*A*' is 70 torr at 27 °C. It forms an ideal solution with another liquid *B*. The mole fraction of *B* in the solution is 0.2 and total pressure of solution is 84 torr at 27 °C. The vapour pressure of pure liquid *B* at 27 °C is
(a) 14 torr (b) 56 torr
(c) 140 torr (d) 70 torr

17. Consider separate solutions of 0.500 M $C_2H_5OH_{(aq)}$, 0.100 M $Mg_3(PO_4)_{2(aq)}$, 0.250 M $KBr_{(aq)}$ and 0.125 M $Na_3PO_{4(aq)}$ at 25° C. Which statement is true about these solutions, assuming all salts to be strong electrolytes?
(a) 0.500 M $C_2H_5OH_{(aq)}$ has the highest osmotic pressure.
(b) They all have the same osmotic pressure.
(c) 0.100 M $Mg_3(PO_4)_{2(aq)}$ has the highest osmotic pressure.
(d) 0.125 M $Na_3PO_{4(aq)}$ has the highest osmotic pressure.

18. In a body-centred cubic lattice given below, the three distances AB, AC and AA' are respectively.



(a) a, $\sqrt{2}a$ and $\dfrac{\sqrt{3}a}{2}$
(b) a, $\dfrac{\sqrt{3}a}{2}$ and $\sqrt{2}a$
(c) $\dfrac{\sqrt{3}a}{2}$, $\sqrt{2}a$ and a
(d) a, $\dfrac{a}{\sqrt{2}}$ and $\dfrac{\sqrt{3}a}{2}$

19. A mineral having the formula AB_2 crystallises in the *ccp* lattice, with A atoms occupying the lattice points. Select the incorrect statement.
(a) The coordination number for A atoms is 8.
(b) The coordination number for B atoms is 4.
(c) 100% of tetrahedral voids are occupied by B atoms.
(d) 50% of tetrahedral voids are occupied by B atoms.

More than One Options Correct Type

20. Which of the following statements are correct about acetone and trichloromethane mixture?
(a) Mixture of acetone and tricholoromethane shows positive deviation from Raoult's law.
(b) The forces of attraction acting between the molecules of acetone and trichloromethane in a mixture are greater than those acting between the molecules in pure acetone.
(c) Pure acetone can be obtained by the careful fractional distillation of any mixture of acetone and trichloromethane.
(d) When acetone and tricholoromethane are mixed, the enthalpy change is negative.

21. Consider following solutions :
0.1 m $C_6H_5NH_3^+Cl^-$; 0.1 m KCl ;
0.1 m glucose ; 0.1 m$Na_2C_2O_4.10H_2O$
Which of the following statements are correct about the given solutions?
(a) The solution with highest boiling point is 0.1 m $Na_2C_2O_4.10H_2O$.
(b) The solution with highest freezing point is 0.1 m glucose.
(c) 0.1 m $C_6H_5NH_3Cl$ and 0.1 m NaCl will have the same osmotic pressure.
(d) 0.1 m glucose solution will have the lowest osmotic pressure.

22. Which of the following statements are not true?
(a) Vacancy defect results in a decrease in the density of the substance.
(b) Interstitial defects results in an increase in the density of the substance.
(c) Impurity defect has no effect on the density of the substance.
(d) Frankel defect results in an increase in the density of the substance.

Vapor transport deposition of antimony selenide thin film solar cells with 7.6% efficiency

Antimony selenide (Sb_2Se_3) has recently emerged as a promising green alternative to CdTe solar cells because it possesses very attractive optoelectronic properties such as proper bandgap for the absorption of a significant portion of the solar spectrum, high optical absorption coefficient and decent carrier mobility. Besides, because it is a binary compound with high vapor pressure, a fast, low temperature vacuum-based deposition technique can be employed like the ones established in CdTe photovoltaics. Furthermore, the earth-abundant elemental compositions of Sb_2Se_3 as well as its easy fabrication promise low-cost manufacturing.

By improving crystallinity of antimony selenide films and then successfully producing superstrate cadmium sulfide/antimony selenide solar cells with a certified power conversion efficiency of 7.6%, a net 2% improvement over previous 5.6% record of the same device configuration has been achieved.

23. The number of tetrahedral voids per unit cell in NaCl crystal is ________.

(a) 4 (b) 8

(c) twice the number of octahedral voids

(d) four times the number of octahedral voids

Numberical Value

24. The vapour pressures of pure liquids *A* and *B* are 450 and 700 mm Hg at 350 K respectively. Total vapour pressure of liquid mixture is 600 mm Hg. Calculate the mole fraction of *B*.

25. A 0.001 molal solution of $[Pt(NH_3)_4Cl_4]$ in water had freezing point depression of 0.0054°C. If K_f for water is 1.80, the number of Cl^- ions furnished is

26. The density of mercury is 13.6 g/mL. Calculate approximately the diameter of an atom of mercury (in Å unit) assuming that each atom is occupying a cube of edge length equal to the diameter of the mercury atom.

Comprehension Type

The electrolyte solutions show abnormal colligative properties. To account for this effect we define a quantity called the van't Hoff factor given by

$$i = \frac{\text{Actual number of particles in solution after dissociation}}{\text{Number of formula units initially dissolved in solution}}$$

$i = 1$ (for non-electrolytes)

$i > 1$ (for electrolytes, undergoing dissociation)

$i < 1$ (for solutes undergoing association)

27. Benzoic acid undergoes dimerisation in benzene solution. The van't Hoff factor (i) is related to the degree of association (α) of the acid as

(a) $i = 2 - \alpha$ (b) $i = 1 + (\alpha/3)$

(c) $i = 1 - (\alpha/2)$ (d) $i = 1 + (\alpha/2)$

28. For a solution of a non-electrolyte in water, the van't Hoff factor is

(a) always equal to 0 (b) ≤ 2

(c) always equal to 1 (d) > 1 but < 2

Matrix Match Type

29. Match the distribution of particles *A* and *B* in column I with formula given in column II.

	Column I		Column II
A.	*A* in *ccp* and *B* is equally distributed in octahedral and tetrahedral voids	p.	A_2B_3
B.	*B* in *hcp* and *A* occupies $2/3^{rd}$ of octahedral voids	q.	A_3B
C.	*A* at the corners and face centres and *B* at edge centres and body centre	r.	AB
D.	*B* in ccp and *A* occupies all the octahedral and tetrahedral sites	s.	AB_2

Codes :

	A	B	C	D
(a)	s	p	r	q
(b)	s	p	q	r
(c)	r	q	p	s
(d)	s	q	r	p

30. Match column I with column II and choose the correct option using the codes given below :

	Column I (Solution)		Column II (Characteristics)
A.	C_2H_5OH - H_2O	p.	$\Delta S > 0$
B.	H_2O - HNO_3	q.	$\Delta V > 0$
C.	CH_3OH- CH_3CH_2OH	r.	$\Delta H < 0$
D.	CCl_4 - toluene	s.	$p_1 > p_1^\circ x_1$

Codes :

	A	B	C	D
(a)	p, q	r, s	p	r, s
(b)	p, q, s	p, r	p	p, q, s
(c)	p, q, r	r, s	p	p, q, r
(d)	p, r, s	p, s	p	r, s

◈◈

Keys are published in this issue. Search now! ☺

CHECK YOUR PERFORMANCE

No. of questions attempted	……
No. of questions correct	……
Marks scored in percentage	……

If your score is

> 80%	Your preparation is going good, keep it up to get high score.
60-80%	Need more practice, try hard to score more next time.
<60%	Stress more on concepts and revise thoroughly.

CHEMISTRY MUSING

PROBLEM SET 60

Chemistry Musing was started from August '13 issue of Chemistry Today. The aim of Chemistry Musing is to augment the chances of bright students preparing for JEE (Main and Advanced) / NEET / AIIMS / JIPMER with additional study material. In every issue of Chemistry Today, 10 challenging problems are proposed in various topics of JEE (Main and Advanced) / NEET. The detailed solutions of these problems will be published in next issue of Chemistry Today.

The readers who have solved five or more problems may send their solutions. The names of those who send atleast five correct solutions will be published in the next issue. We hope that our readers will enrich their problem solving skills through "Chemistry Musing" and stand in better stead while facing the competitive exams.

JEE MAIN/NEET

1. A certain compound (X) shows the following reactions :

(i) When KI is added to an aqueous suspension of (X) containing acetic acid, iodine is liberated.

(ii) When CO_2 is passed through an aqueous suspension of (X), the turbidity transforms to a precipitate.

(iii) When X is heated with ethyl alcohol, a product of anaesthetic use is obtained.

Identify (X).

(a) $CaCl_2$ (b) Cl_2

(c) $CaOCl_2$ (d) $CaCO_3$

2. Which of the following is correct related to change in aluminium oxide?

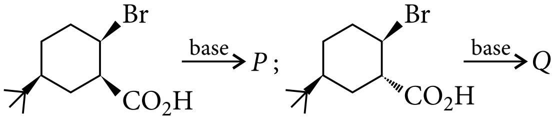
(a) $Al_2O_3 \xrightarrow{\text{dil.HCl}} AlO_2^- \xrightarrow[\text{NaOH}]{\text{conc.}} Al(OH)_3 \xrightarrow{\Delta} Al_2O_3$

(b) $Al_2O_3 \xrightarrow{\text{conc. NaOH}} AlO_2^- \xrightarrow{\text{dil.HCl}} Al(OH)_3 \xrightarrow{\text{conc. } H_2SO_4} Al_2O_3$

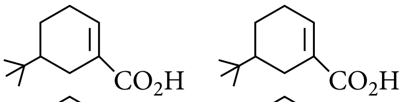
(c) $Al_2O_3 \xrightarrow{\text{conc. NaOH}} AlO_2^- \xrightarrow{\text{dil.HCl}} Al(OH)_3 \xrightarrow{\Delta} Al_2O_3$

(d) $Al_2O_3 \xrightarrow{\text{conc. HCl}} AlO_2^- \xrightarrow{\text{conc. NaOH}} Al(OH)_3 \xrightarrow{\Delta} Al_2O_3$

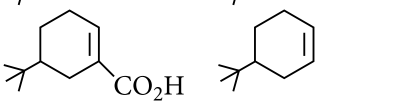
3. Identify the products of the following reactions :

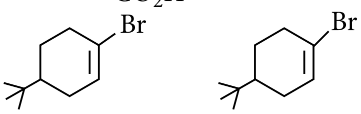


P **Q**

(a) 

(b) 

(c) 

(d) 

4. For $[Cr(H_2O)_6]^{2+}$ ion, the mean pairing energy, P is found to be 23500 cm^{-1}. The magnitude of Δ_o is 13900 cm^{-1}. What will be the crystal field stabilisation energy for the complex in configurations corresponding to high spin and low spin states respectively. Which is more stable?

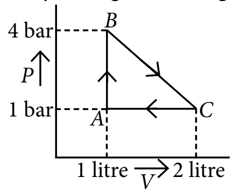
(a) $-5560\ cm^{-1}$, $+1260\ cm^{-1}$; High spin

(b) $-1260\ cm^{-1}$, $+8340\ cm^{-1}$; Low spin

(c) $-8340\ cm^{-1}$, $+1260\ cm^{-1}$; High spin

(d) $-1260\ cm^{-1}$, $+5560\ cm^{-1}$; Low spin

5. One mole of an ideal gas is carried through the reversible cyclic process as shown in figure. The maximum temperature attained by the gas during the cycle is



(a) $\frac{7}{6R}$

(b) $\frac{12}{49R}$

(c) $\frac{49}{12R}$ (d) none of these.

JEE ADVANCED

6. Assume that air contains 79% N_2 and 21% O_2 by volume. Calculate the density of moist air at 25 °C and 1 atm pressure when relative humidity is 60%. The vapour pressure of water at 25°C is 23.78 mm of Hg. Relative humidity is given by percentage : Relative humidity

$$= \frac{\text{Partial pressure of water}}{\text{Vapour pressure of water at that temperature}} \times 100$$

(a) 1.98 g/L (b) 1.17 g/L

(c) 2.58 g/L (d) 0.35 g/L

COMPREHENSION

$F \xrightarrow{\text{NaOI}}$ (–)ve iodoform test

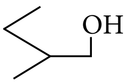
$F \xrightarrow[\text{HCl}]{ZnCl_2}$ Immediate turbidity

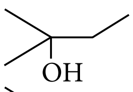
$F \xrightarrow{\text{dil. } H_2SO_4}$ Compound A (C_4H_8) $\xrightarrow{\text{Hot conc. } KMnO_4}$ B + C(gas) $\xrightarrow{\text{NaOI}}$ D + E (yellow)

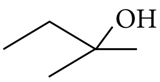
7. Compound $B \xrightarrow{\underset{\text{PPh}_3}{\overset{\text{CH–CH}_3}{\|}}}$ X-compound

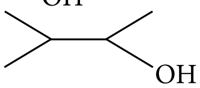
$\xrightarrow[\text{(2) NaOH/H}_2\text{O}_2]{\text{(1) B}_2\text{H}_6\text{–THF}}$ Y-compound

Identify the structure of compound Y.

(a) 

(b) 

(c) 

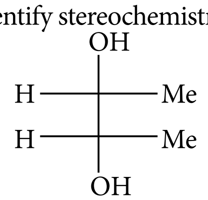
(d) 

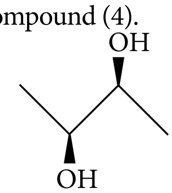
8. Compound $E \xrightarrow{\text{Ag}/\Delta}$ Compound (1) $\xrightarrow[\text{(2) 2eq. CH}_3\text{I}]{\text{(1) 2eq.NaNH}_2}$

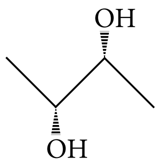
Compound (2) $\xrightarrow[\text{H}_2]{\text{Pd/BaSO}_4}$ Compound (3) $\xrightarrow[\text{(2) NaHSO}_3\text{ (aq.)}]{\text{(1) OsO}_4}$

Compound (4)

Identify stereochemistry of compound (4).

(a) 

(b) 

(c) 

(d) Both (b) and (c)

INTEGER VALUE

9. The chlorate ion can disproportionate in basic solution according to reaction,

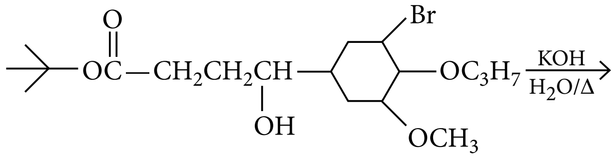
$$2ClO_3^- \rightleftharpoons ClO_2^- + ClO_4^-$$

If the equilibrium concentration of perchlorate ions from a solution initially at 0.1 M in chlorate ions at 298 K is $a \times 10^{-2}$, then a is

(Given : $E^o_{ClO_4^-|ClO_3^-} = 0.36$ V and

$E^o_{ClO_3^-|ClO_2^-} = 0.33$ V at 298 K)

10. Total number of products obtained in following reaction is



UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

Column I	Column II
1. DRRBEEE	(a) The substances which when added to some other substances to make them unfit for human use
2. XSPREEP	(b) Dilute solutions containing the water-soluble components of vegetable drugs prepared by aqueous extraction of the drugs
3. MLOOGNIB	(c) A trade name for cast polymethyl methacrylate sheet (an acrylic resin)
4. TANRUSTNAED	(d) Most common commercial form of zinc metal having 3% impurities mainly lead
5. ORLDNAAESSALVOT	(e) A reactor which produces more fissionable nuclei than that it consumes
6. SHCEHO	(f) The white cloudy appearance sometimes seen on the surface of vulcanised rubber and caused by the separation of sulphur crystal
7. RELPTSE	(g) Common name of prop-1-ene-1, 2, 3-tricarboxylic acid found in sugarcane and beetroot
8. ACDTINIOCACI	(h) The name given to an antibiotic extracted from *Streptomyces* fungi with an interesting tricyclic structure
9. OFSIUNSNI	(i) A reaction used to synthesize 1-(2, 4, 6-trihydroxyphenyl)ethanone from phloroglucinol
10. TNELACOEONLANTEP	(j) An italian physicist, chemist who was credited as inventor of the electrical battery and the discoverer of methane

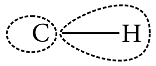
Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month to win exciting prizes. Winners' names will be published in next issue.

ADVANCED CHEMISTRY BLOC

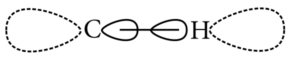
(Concept of Anti-bonding Orbitals and Their Role in Explaining Chemical Phenomena)

The central theme of molecular orbital theory (MOT) is the linear combination of atomic orbitals (LCAO). Two atomic orbitals combine to produce two molecular orbitals, one of them is anti-bonding molecular orbital. It is true that MOT is relatively complex as compared to VBT but the role of anti-bonding orbital in the explanation of certain phenomena has been remarkable.

Before you begin, see the location of anti-bonding orbital. It lies on the same axis as the bonding orbital. For a C – H bond, two orbitals, bonding and anti-bonding orbitals are shown in separate diagrams.



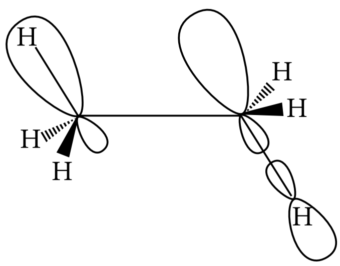
C – H σ orbital



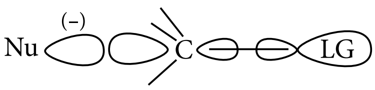
C – H σ* orbital

We know that highest occupied molecular orbitals (HOMO) in oxygen are $(\pi_x^*)^1 = (\pi_y^*)^1$ and oxygen is paramagnetic with bond order two. When two hydrogen atoms combine with one O_2 molecule to form H_2O_2 they push electrons to these anti-bonding orbitals making them fully-filled and reducing the bond order to one. But what about O_2F_2, two fluorine atoms are a bit reluctant to give electrons to oxygen atoms. Though they bind with O_2 molecule but do not fill the anti-bonding orbitals effectively owing to their higher electronegativity. Consequently the O — O bond order in O_2 molecule is not reduced to one. In other words, the O — O bond length in O_2F_2 is smaller than that in H_2O_2.

The eclipsed conformation of ethane is less stable than its staggered form. Besides the relaxation from steric factor, the stabilising interaction between the C — H σ-bonding orbital on one carbon atom with the C — H σ* anti-bonding orbital on the other carbon atom is partly responsible. This interaction is greatest when the two orbitals are exactly parallel.

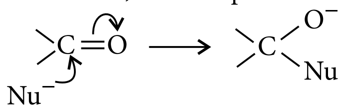


In S_N2 reaction, the incoming nucleophile approaches the leaving group (LG) exactly from opposite side. The anti-bonding orbital of C — LG bond lies on the same axis as the bonding axis.

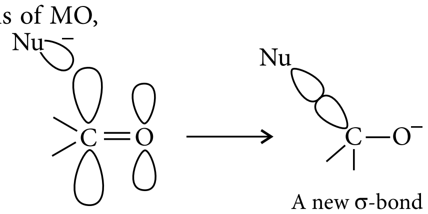


As the nucleophile fills the anti-bonding orbital, the bond between C — LG breaks. This explains the typical backside attack behaviour of S_N2.

In the addition reactions, the nucleophile attacks >C=O group.



In terms of MO,



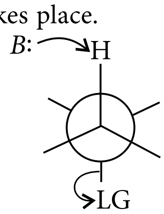
Electrons from nucleophile begin to interact with π* orbital

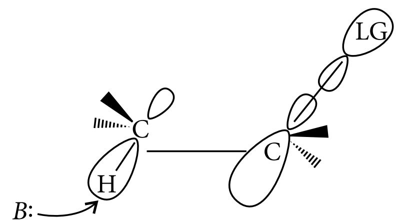
A new σ-bond is formed

As you can notice that the size of lobes on oxygen are smaller as compared to those on carbon. With higher electronegativity, oxygen contributes more to bonding orbital and less to anti-bonding orbital.

The leaving groups must have anti-periplanar arrangement in E2 reaction just before the reaction takes place.

In terms of MO, the C — H bonding electron slowly move to anti-bonding orbital of C — LG bond as the base removes the proton. This smooth transfer is most effective in anti-periplanar rearrangement.





PF_3 : A π-acid ligand accepts back donation from metal. The anti-bonding P — F sigma orbital is well positioned in space to accept the donation.

In Birch reduction, Na pushes electrons to the anti-bonding π* orbital of non-terminal alkyne, which in turn becomes a radical anion. The radical anion then accepts proton from solvent ammonia to form alkene.

YOU ASK WE ANSWER

Do you have a question that you just can't get answered?
Use the vast expertise of our MTG team to get to the bottom of the question. From the serious to the silly, the controversial to the trivial, the team will tackle the questions, easy and tough. The best questions and their solutions will be printed in this column each month.

1. Does hybridisation occur only in central atoms? If so, why hybridisation occurs in O atom in CO_2 molecule? *(Subhadeep Mondal, West Bengal)*

Ans. Hybridisation is the concept of mixing atomic orbitals of nearly same energy to produce a set of entirely new hybrid orbitals (with different energies, shapes, etc. than the atomic orbitals) suitable for the pairing of electrons to form a chemical bonds. Hybridisation is a model we use to describe bonding.

All atoms with *p* or *d*-orbitals can hybridise in a molecule, not just the central atom. We only use hybridisation for central atom to determine the shape of the molecule, however it is not needed to describe the hybridisation of peripheral atoms although peripheral atoms are also undergoing hybridisation.

In CO_2, the central atom C is *sp*-hybridised which determines the shape of CO_2 molecule which is linear. O atom in CO_2 is sp^2-hybridised.

It is important to remember that the hybridised state is a theoretical step in going from an atom to a molecule and hybridised state never actually exists.

2. What is pi-back donation which occurs in BF_3 and PF_3 molecules? *(Subhadeep Mondal, West Bengal)*

Ans. π-back bonding or back bonding occurs between parallel orbitals (any two *p* or *d*-orbitals or a mixture of both) of appropriate energies.

This type of bonding is possible between atoms in a compound in which one atom has lone pair of electrons and the other has vacant orbital placed adjacent to each other. Consequently, the bonding acquires a partial double bond character.

In π-back bonding, the electrons move from an atomic orbital to a π^* anti-bonding orbital on another atom or ligand.

In BF_3, since the size of vacant 2*p*-orbital of B and 2*p*-orbital of F containing a lone pair of electrons are almost identical, therefore, the lone pair of electrons on F is donated towards B atom. Thus, a dative π bond is formed. In PF_3, P has vacant *d*-orbital which can perform back bonding with fluorine.

3. What freezes faster – cold water or hot water? *(S. Deshmukh, Maharashtra)*

Ans. Hot water freezes faster than cold water. This phenomenon is known as Mpemba effect. Hot water evaporates faster than cold water, thus reducing the amount of water left to be frozen. Thus, the initially warmer water can freeze before the initially cooler water, but ice formed will be less. This assumes that water loses heat solely through evaporation.

On the basis of bonding, when the water warms up, the hydrogen bonds stretch and the water molecules move further apart. This allows the relaxation of covalent bonds, which causes water molecules to give up their energy. The process of covalent bonds giving up their energy is essentially the same as cooling. Hence, warm water cools faster than cold water.

MtG Team Applauds

Abhijeet Kadam & Prashant Wayal

Cracking NEET 2018

- **MTG : Why did you choose medical entrance?**
  Prashant : I chose medical entrance because this field has job assurance, self satisfaction, respect in society and also it allows to directly serve the people.
  Abhijeet : I chose medical entrance because I want to become a good doctor and serve the society.
- **MTG : What exams have you appeared for and what is your ranks in these exams?**
  Prashant : I have appeared for NEET. My NEET AIR is 64 (10^{th} in OBC). I have appeared for MHT-CET and secured 1^{st} state rank in OBC. I have also been awarded with KVPY fellowship.
  Abhijeet : I have appeared for NEET exam. My NEET AIR is 98. In MHT-CET I got 1st rank in Maharashtra state. Apart from this, I have appeared for AIIMS and JIPMER.
- **MTG : Any other achievements? (Please mention the name of exams and rank.)**
  Prashant : I stood first in my college (Yeshwant Mahavidyalaya) in Maharashtra Board Examinations with 611/650 marks (94%).
- **MTG : How did you prepare for NEET and other medical exams?**
  Prashant : I mainly focussed on concepts by solving questions of different types rather than solving bulk of questions of same type.
  Abhijeet : I used to complete my work given in the class. I used to solve MTG MCQ books which helped me a lot.
- **MTG : What basic difference you found in various papers you cleared?**
  Prashant : The difference is just the name of the exam and difficulty level of questions. Syllabus of them is nearly same, revolving around similar basic concepts.
  Abhijeet : In various papers, different questions were asked. Actually, those were not totally different but asked in a different way.

> We cannot master a concept just by reading it many times, it must be supplemented with ample practice and revision. We should start reading between the lines and always share our thoughts with teachers.
>
> Prashant
>
> ❖❖❖
>
> The only thing I would like to mention here is that, never give up and keep trying. At last success will kneel down in front of you.
>
> Abhijeet

- **MTG : How many hours in a day did you study to prepare for the examinations?**
  Prashant : The hours were not fixed. It depended on my mood and interest. Somedays I did not even see the books while somedays I sat until I completed my target. I never studied more than 6 hours.
  Abhijeet : I didn't have fixed time for study. The only aim was to finish my work whatever time it may require. Sometimes, I used to study whole night so as to complete my work.
- **MTG : On which topics and chapters you laid more stress in each subject?**
  Prashant : In chemistry, I focussed more on inorganic chemistry as it requires regular brush up. In physics, I focussed more on optics, mechanics and electrostatics. In biology, I focussed more on genetics and ecology.
  Abhijeet : In physics, I gave more stress on optics because it is a bit difficult topic. Inorganic chemistry also required more stress. In biology, I gave more stress on human physiology topics.
- **MTG : How much time does one require for serious preparation for this exam?**
  Prashant : Regular 3 hours of study and having full devotion is enough to crack any exam.
  Abhijeet : I think, one must give appropriate time to each subject. But sometimes, if any topic is difficult whether it is physics, chemistry or biology, then we have to spend more time on it.
- **MTG : Which subjects/topics were you strong/weak at?**
  Prashant : I was strong at Physics and Chemistry but I used to get bored while mugging up the biology statistics.
  Abhijeet : I didn't find any subject difficult. Only some topics required more stress.
- **MTG : Which Books/Magazines/ Tutorial/Coaching classes you followed?**

Prashant : I attended Ideal Institute of Biology, Creative Coaching Classes for Physics and Konale Chemistry Classes and their study material.

Abhijeet : For biology, I joined Ideal Institute of Biology (IIB). For physics, I studied in Creative Coaching Classes. For chemistry, I preferred Konale Coaching Classes. No any other extra coaching. I used to follow MTG publication books, magazines, NCERT exemplars.

- **MTG : In your words, what are the components of an ideal preparation plan?**

  Prashant : We should never miss our regular classes, complemented with regular fixed hours of study and most important is healthy habits and good diet.

  Abhijeet : According to me, concentration and perseverance are the components of an ideal preparation plan.

- **MTG : What role did the following play in your success (a) Parents (b) Teachers (c) School?**

  Prashant : (a) Parents : My parents specially played a very important role in maintaining my health before exams which is a very important aspect in my result.

  (b) Teachers : They guided me about how to prepare for various exams. They added limits to the extent of study and mapped my entire journey.

  (c) School : School helped me by providing a strong foundation.

  Abhijeet : (a) Parents : They played the best role in my success. They took care of my each and everything. They provided me the best so as to get success.

  (b) Teachers : They are my next parents. Their teaching cleared all my topics, so I didn't find any subject tough.

  (c) School : School inculcated all the good values in me. They made my fundamental concepts strong which proved helpful.

- **MTG : Your family background?**

  Prashant : I am basically from a village called Baygon Bk in Buldhana district, Maharashtra. My father is a teacher whereas my mother is a housewife.

  Abhijeet : My father is a primary teacher in a village. We belong to village and farming is our main occupation.

- **MTG : What mistake you think you shouldn't have made?**

  Prashant : I shouldn't have underestimated myself. I was also too lethargic. I think I should have been more focussed and active.

  Abhijeet : I think that I shouldn't have taken some topics lightly. Because of this negligence, I wouldn't answer most easy questions correctly.

- **MTG : How did you de-stress yourself during the preparation? Share your hobbies and how often you could pursue them?**

  Prashant : I regularly used to watch movies (specially comedy ones). Daily at time of lunch and dinner, I used to watch a movie for 40 minutes. I also used to watch WWE, cricket matches, etc.

  Abhijeet : When I would feel stress, then I used to do meditation and de-stress myself. My hobby was playing cricket. I used to play cricket in my free time.

- **MTG : How have various MTG products like Explorer Books and Magazines helped you in your preparation?**

  Prashant : I used Biology Today, Physics For you and Chemistry Today. They kept me updated with questions from various national exams and olympiads. I also used Fingertips, NEET Explorer and 30 Years book which gave me a similar set of questions as asked in NEET.

  Abhijeet : MTG has played a great role in my preparation, because the information provided by them is really helpful and worth preparing.

- **MTG : Had you not been selected then what would have been your future plan?**

  Prashant : My aim is to become world's richest person. So, I definitely, though selected or not, would have started my own business. Being a young Indian Entrepreneur always fascinates me.

  Abhijeet : If I wouldn't have been selected, then I would have attempted next time with more energy and enthusiasm and perseverance.

- **MTG : What do you think is the secret of your success?**

  Prashant : I never thought of exams as a burden or my goal. I enjoyed learning new concepts and thinking about how life could have been without them. I always studied as it was fun and only when I was interested I took the book. It was goal-less reading just for fun.

  Abhijeet : I think, "Success in life is a matter, not so much of talent or opportunity, as of concentration and perseverance".

- **MTG : What advice would you like to give our readers who are PMT aspirants?**

  Prashant : We cannot master a concept just by reading it many times, it must be supplemented with ample practice and revision. We should start reading between the lines and always share our thoughts with teachers.

  Abhijeet : The only thing I would like to mention here is that, never give up and keep trying. At last success will kneel down in front of you.

All the Best!☺☺

PAPER-I

Section 1 (Maximum Marks : 24)

- *This section contains SIX (06) questions.*
- *Each question has FOUR options for correct answer(s). ONE OR MORE THAN ONE of these four option(s) is (are) correct option(s).*
- *For each question, choose the correct option(s) to answer the question.*
- *Answer to each question will be evaluated according to the following marking scheme:*

Full Marks :	+4	*If only (all) the correct option(s) is (are) chosen.*
Partial Marks :	+3	*If all the four options are correct but ONLY three options are chosen.*
Partial Marks :	+2	*If three or more options are correct but ONLY two options are chosen, both of which are correct options.*
Partial Marks :	+1	*If two or more options are correct but ONLY one option is chosen and it is a correct option.*
Zero Marks :	0	*If none of the options is chosen (i.e. the question is unanswered).*
Negative Marks :	–2	*In all other cases.*

- *For Example: If first, third and fourth are the ONLY three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option) ,without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in –2 marks.*

1. The compound(s) which generate(s) N_2 gas upon thermal decomposition below 300 °C is (are)

(a) NH_4NO_3 (b) $(NH_4)_2Cr_2O_7$
(c) $Ba(N_3)_2$ (d) Mg_3N_2

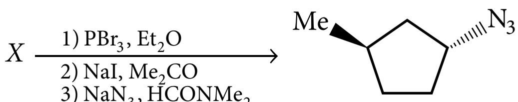
2. The correct statement(s) regarding the binary transition metal carbonyl compounds is (are)
(Atomic numbers: Fe = 26, Ni = 28)

(a) total number of valence shell electrons at metal centre in $Fe(CO)_5$ or $Ni(CO)_4$ is 16
(b) these are predominantly low spin in nature
(c) metal–carbon bond strengthens when the oxidation state of the metal is lowered
(d) the carbonyl C—O bond weakens when the oxidation state of the metal is increased.

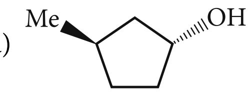
3. Based on the compounds of group 15 elements, the correct statement(s) is (are)

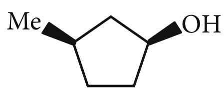
(a) Bi_2O_5 is more basic than N_2O_5
(b) NF_3 is more covalent than BiF_3
(c) PH_3 boils at lower temperature than NH_3
(d) the N—N single bond is stronger than the P—P single bond.

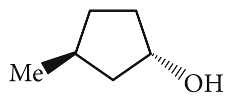
4. In the following reaction sequence, the correct structure(s) of *X* is (are)

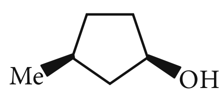


Enantiomerically pure

(a) 

(b) 

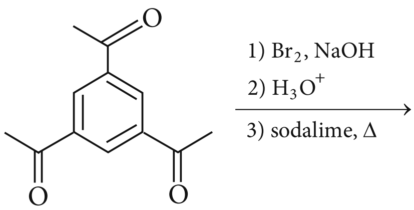
(c) 

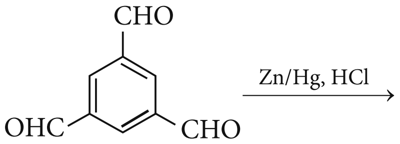
(d) 

5. The reaction(s) leading to the formation of 1,3,5-trimethylbenzene is (are)

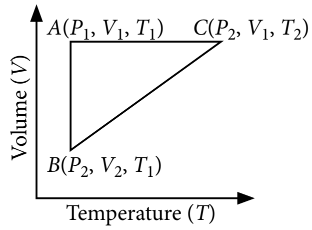
(a) 

(b) $Me—\!\equiv\!—H \xrightarrow[873K]{\text{heated iron tube}}$

(c) 

(d) 

6. A reversible cyclic process for an ideal gas is shown below. Here, P, V and T are pressure, volume and temperature, respectively. The thermodynamic parameters q, w, H and U are heat, work, enthalpy and internal energy, respectively.



The correct option(s) is (are)

(a) $q_{AC} = \Delta U_{BC}$ and $w_{AB} = P_2(V_2 - V_1)$

(b) $w_{BC} = P_2(V_2 - V_1)$ and $q_{BC} = \Delta H_{AC}$

(c) $\Delta H_{CA} < \Delta U_{CA}$ and $q_{AC} = \Delta U_{BC}$

(d) $q_{BC} = \Delta H_{AC}$ and $\Delta H_{CA} > \Delta U_{CA}$

Section 2 (Maximum Marks : 24)

- *This section contains EIGHT (08) questions. The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.*
- ***Answer to each question will be evaluated according to the following marking scheme:***

  Full Marks : +3 *If ONLY the correct numerical value is entered as answer.*

  Zero Marks : 0 *In all other cases.*

7. Among the species given below, the total number of diamagnetic species is ____.
H atom, NO_2 monomer, O_2^- (superoxide), dimeric sulphur in vapour phase, Mn_3O_4, $(NH_4)_2[FeCl_4]$, $(NH_4)_2[NiCl_4]$, K_2MnO_4, K_2CrO_4

8. The ammonia prepared by treating ammonium sulphate with calcium hydroxide is completely used by $NiCl_2.6H_2O$ to form a stable coordination compound. Assume that both the reactions are 100% complete. If 1584 g of ammonium sulphate and 952 g of $NiCl_2.6H_2O$ are used in the preparation, the combined weight (in grams) of gypsum and the nickel-ammonia coordination compound thus produced is ____.
(Atomic weights in g mol^{-1}: H = 1, N = 14, O = 16, S = 32, Cl = 35.5, Ca = 40, Ni = 59)

9. Consider an ionic solid MX with NaCl structure. Construct a new structure (Z) whose unit cell is constructed from the unit cell of MX following the sequential instructions given below. Neglect the charge balance.

(i) Remove all the anions (X) except the central one

(ii) Replace all the face centered cations (M) by anions (X)

(iii) Remove all the corner cations (M)

(iv) Replace the central anion (X) with cation (M)

The value of $\left(\dfrac{\text{number of anions}}{\text{number of cations}}\right)$ in Z is _____ .

10. For the electrochemical cell,
$Mg(s) \mid Mg^{2+}$ (aq, 1 M) $\parallel Cu^{2+}$ (aq, 1 M) $\mid Cu(s)$
the standard emf of the cell is 2.70 V at 300 K. When the concentration of Mg^{2+} is changed to x M, the cell potential changes to 2.67 V at 300 K. The value of x is ____ .
(Given, $\dfrac{F}{R} = 11500$ K V^{-1}, where F is the Faraday constant and R is the gas constant, ln(10) = 2.30)

11. A closed tank has two compartments A and B, both filled with oxygen (assumed to be ideal gas). The partition separating the two compartments is fixed and is a perfect heat insulator (Figure 1). If the old partition is replaced by a new partition which can slide and conduct heat but does **NOT** allow the gas to leak across (Figure 2), the volume (in m^3) of the compartment A after the system attains equilibrium is ____.

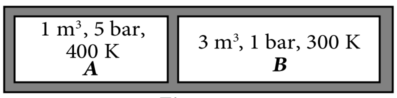


Figure 1

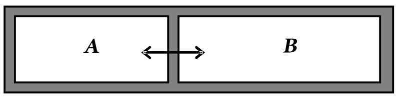
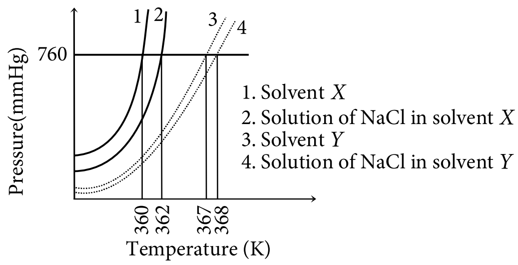


Figure 2

12. Liquids A and B form ideal solution over the entire range of composition. At temperature T, equimolar binary solution of liquids A and B has vapour pressure 45 Torr. At the same temperature, a new solution of A and B having mole fractions x_A and x_B, respectively, has vapour pressure of 22.5 Torr. The value of x_A/x_B in the new solution is ____.
(Given that the vapour pressure of pure liquid A is 20 Torr at temperature T)

13. The solubility of a salt of weak acid (AB) at pH 3 is $Y \times 10^{-3}$ mol L^{-1}. The value of Y is ____.
(Given that the value of solubility product of AB $(K_{sp}) = 2\times10^{-10}$ and the value of ionization constant of HB $(K_a) = 1\times10^{-8}$)

14. The plot given below shows P—T curves (where P is the pressure and T is the temperature) for two solvents X and Y and isomolal solutions of NaCl in these solvents. NaCl completely dissociates in both the solvents.



On addition of equal number of moles of a non-volatile solute S in equal amount (in kg) of these solvents, the elevation of boiling point of solvent X is three times that of solvent Y. Solute S is known to undergo dimerization in these solvents. If the degree of dimerization is 0.7 in solvent Y, the degree of dimerization in solvent X is ____.

Section 3 (Maximum Marks : 12)

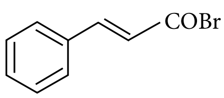
- *This section contains TWO (02) paragraphs. Based on each paragraph, there are TWO (02) questions.*
- *Each question has FOUR options. ONLY ONE of these four options corresponds to the correct answer.*
- *For each question, choose the option corresponding to the correct answer.*
- ***Answer to each question will be evaluated according to the following marking scheme:***

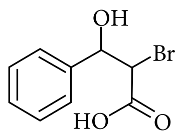
Full Marks : +3 *If ONLY the correct option is chosen.*
Zero Marks : 0 *If none of the options is chosen (i.e. the question is unanswered).*
Negative Marks : −1 *In all other cases.*

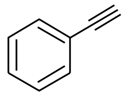
PARAGRAPH-I

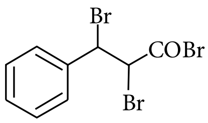
Treatment of benzene with CO/HCl in the presence of anhydrous $AlCl_3/CuCl$ followed by reaction with $Ac_2O/NaOAc$ gives compound X as the major product. Compound X upon reaction with Br_2/Na_2CO_3, followed by heating at 473 K with moist KOH furnishes Y as the major product. Reaction of X with H_2/Pd-C, followed by H_3PO_4 treatment gives Z as the major product.

15. The compound Y is

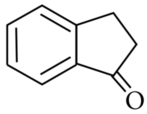
(a) 

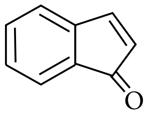
(b) 

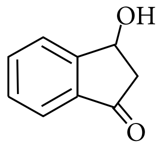
(c) 

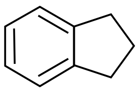
(d) 

16. The compound Z is

(a) 

(b) 

(c) 

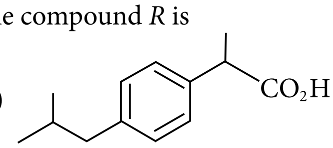
(d) 

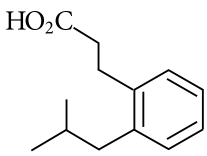
PARAGRAPH-II

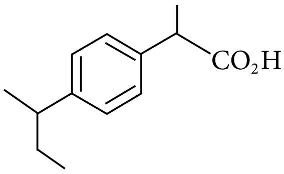
An organic acid P $(C_{11}H_{12}O_2)$ can easily be oxidized to a dibasic acid which reacts with ethylene glycol to produce a polymer dacron. Upon ozonolysis, P gives an aliphatic ketone as one of the products. P undergoes the following reaction sequences to furnish R via Q. The compound P also undergoes another set of reactions to produce S.

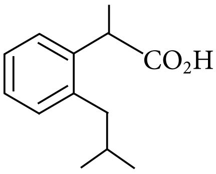
$$S \xleftarrow[\substack{4)\ CHCl_3,\ KOH,\ \Delta \\ 5)\ H_2/Pd\text{-}C}]{\substack{1)\ H_2/Pd\text{-}C \\ 2)\ NH_3/\Delta \\ 3)\ Br_2/NaOH}} P \xrightarrow[\substack{3)\ MeMgBr, CdCl_2 \\ 4)\ NaBH_4}]{\substack{1)\ H_2/Pd\text{-}C \\ 2)\ SOCl_2}} Q \xrightarrow[\substack{3)\ CO_2\ (\text{Dry ice}) \\ 4)\ H_3O^+}]{\substack{1)\ HCl \\ 2)\ Mg/Et_2O}} R$$

17. The compound R is

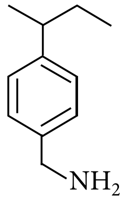
(a) 

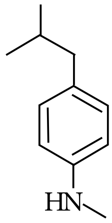
(b) 

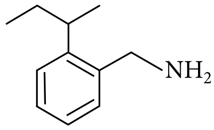
(c) 

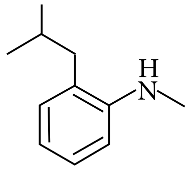
(d) 

18. The compound *S* is

(a) 

(b) 

(c) 

(d) 

PAPER-II

Section 1 (Maximum Marks : 24)

- *This section contains SIX (06) questions.*
- *Each question has FOUR options for correct answer(s). ONE OR MORE THAN ONE of these four option(s) is (are) correct option(s).*
- *For each question, choose the correct option(s) to answer the question.*
- ***Answer to each question will be evaluated according to the following marking scheme:***

Full Marks :	+4	*If only (all) the correct option(s) is (are) chosen.*
Partial Marks :	+3	*If all the four options are correct but ONLY three options are chosen.*
Partial Marks :	+2	*If three or more options are correct but ONLY two options are chosen, both of which are correct options.*
Partial Marks :	+1	*If two or more options are correct but ONLY one option is chosen and it is a correct option.*
Zero Marks :	0	*If none of the options is chosen (i.e. the question is unanswered).*
Negative Marks :	–2	*In all other cases.*

- *For Example: If first, third and fourth are the ONLY three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option) ,without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in –2 marks.*

1. The correct option(s) regarding the complex $[Co(en)(NH_3)_3(H_2O)]^{3+}$ ($en = H_2NCH_2CH_2NH_2$) is (are)

(a) it has two geometrical isomers

(b) it will have three geometrical isomers if bidentate '*en*' is replaced by two cyanide ligands

(c) it is paramagnetic

(d) it absorbs light at longer wavelength as compared to $[Co(en)(NH_3)_4]^{3+}$.

2. The correct option(s) to distinguish nitrate salts of Mn^{2+} and Cu^{2+} taken separately is (are)

(a) Mn^{2+} shows the characteristic green colour in the flame test

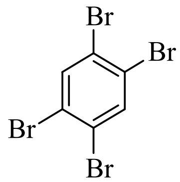
(b) only Cu^{2+} shows the formation of precipitate by passing H_2S in acidic medium

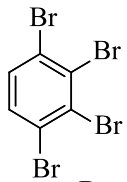
(c) only Mn^{2+} shows the formation of precipitate by passing H_2S in faintly basic medium

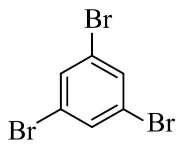
(d) Cu^{2+}/Cu has higher reduction potential than Mn^{2+}/Mn (measured under similar conditions).

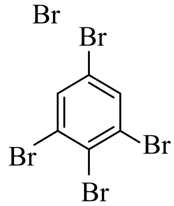
3. Aniline reacts with mixed acid (conc. HNO_3 and conc. H_2SO_4) at 288 K to give *P* (51 %), *Q* (47%) and *R* (2%). The major product(s) of the following reaction sequence is (are)

$$R \xrightarrow[\substack{3)\ H_3O^+ \\ 4)\ NaNO_2,\ HCl/273\text{-}278K \\ 5)\ EtOH,\ \Delta}]{\substack{1)\ Ac_2O,\ Pyridine \\ 2)\ Br_2,\ CH_3CO_2H}} S \xrightarrow[\substack{3)\ NaNO_2,\ HCl/273\text{-}278K \\ 4)\ H_3PO_2}]{\substack{1)\ Sn/HCl \\ 2)\ Br_2/H_2O\ (excess)}} \text{Major product(s)}$$

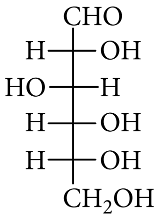
(a) 

(b) 

(c) 

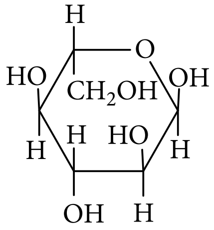
(d) 

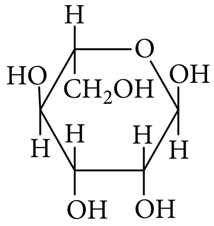
4. The Fischer presentation of *D*-glucose is given below.

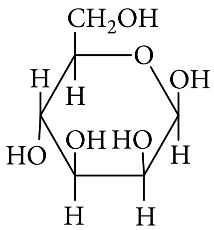


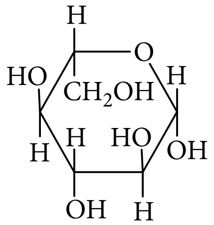
D-glucose

The correct structure(s) of β-*L*-glucopyranose is (are)

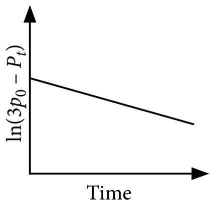
(a) 

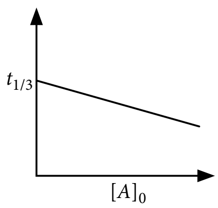
(b) 

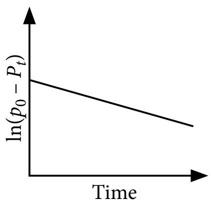
(c) 

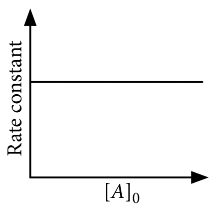
(d) 

5. For a first order reaction $A_{(g)} \rightarrow 2B_{(g)} + C_{(g)}$ at constant volume and 300 K, the total pressure at the beginning ($t = 0$) and at time t are P_0 and P_t, respectively. Initially, only A is present with concentration $[A]_0$, and $t_{1/3}$ is the time required for the partial pressure of A to reach $1/3^{\text{rd}}$ of its initial value. The correct option(s) is (are) (Assume that all these gases behave as ideal gases)

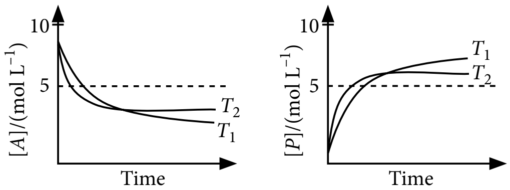
(a) 

(b) 

(c) 

(d) 

6. For a reaction, $A \rightleftharpoons P$, the plots of $[A]$ and $[P]$ with time at temperatures T_1 and T_2 are given below.



If $T_2 > T_1$, the correct statement(s) is (are) (Assume ΔH° and ΔS° are independent of temperature and ratio of ln$K$ at T_1 to ln$K$ at T_2 is greater than T_2/T_1. Here H, S, G and K are enthalpy, entropy, Gibbs energy and equilibrium constant, respectively.)

(a) $\Delta H^\circ < 0, \Delta S^\circ < 0$ (b) $\Delta G^\circ < 0, \Delta H^\circ > 0$
(c) $\Delta G^\circ < 0, \Delta S^\circ < 0$ (d) $\Delta G^\circ < 0, \Delta S^\circ > 0$

Section 2 (Maximum Marks : 24)

- *This section contains EIGHT (08) questions. The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.*
- ***Answer to each question will be evaluated according to the following marking scheme:***

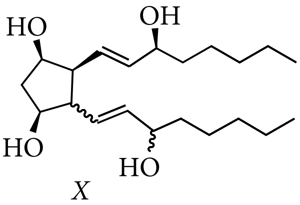
Full Marks : +3 *If ONLY the correct numerical value is entered as answer.*
Zero Marks : 0 *In all other cases.*

7. The total number of compounds having at least one bridging oxo group among the molecules given below is ________ .
N_2O_3, N_2O_5, P_4O_6, P_4O_7, $H_4P_2O_5$, $H_5P_3O_{10}$, $H_2S_2O_3$, $H_2S_2O_5$

8. Galena (an ore) is partially oxidized by passing air through it at high temperature. After some time, the passage of air is stopped, but the heating is continued in a closed furnace such that the contents undergo self-reduction. The weight (in kg) of Pb produced per kg of O_2 consumed is ______.
(Atomic weights in g mol^{-1} : O = 16, S = 32, Pb = 207)

9. To measure the quantity of $MnCl_2$ dissolved in an aqueous solution, it was completely converted to $KMnO_4$ using the reaction,
$MnCl_2 + K_2S_2O_8 + H_2O \rightarrow KMnO_4 + H_2SO_4 + HCl$
(equation not balanced)
Few drops of concentrated HCl were added to this solution and gently warmed. Further, oxalic acid (225 mg) was added in portions till the colour of the permanganate ion disappeared. The quantity of $MnCl_2$ (in mg) present in the initial solution is ______ .
(Atomic weights in g mol^{-1}: Mn = 55, Cl = 35.5)

10. For the given compound X, the total number of optically active stereoisomers is ______ .



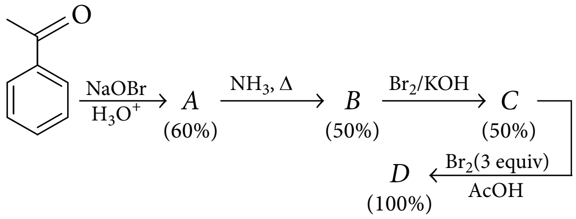
X

This type of bond indicates that the configuration at the specific carbon and the geometry of the double bond is fixed.

This type of bond indicates that the configuration at the specific carbon and the geometry of the double bond is **NOT** fixed.

11. In the following reaction sequence, the amount of D (in g) formed from 10 moles of acetophenone is ______ .

(Atomic weights in g mol^{-1}: H = 1, C = 12, N = 14, O = 16, Br = 80. The yield (%) corresponding to the product in each step is given in the parenthesis.)



12. The surface of copper gets tarnished by the formation of copper oxide. N_2 gas was passed to prevent the oxide formation during heating of copper at 1250 K. However, the N_2 gas contains 1 mole % of water vapour as impurity. The water vapour oxidises copper as per the reaction given below :

$2Cu_{(s)} + H_2O_{(g)} \rightarrow Cu_2O_{(s)} + H_{2(g)}$

p_{H_2} is the minimum partial pressure of H_2 (in bar) needed to prevent the oxidation at 1250 K. The value of $\ln(p_{H_2})$ is ______ .

(Given: total pressure = 1 bar, R (universal gas constant) = 8 J K^{-1} mol^{-1}, ln(10) = 2.3, $Cu_{(s)}$ and $Cu_2O_{(s)}$ are mutually immiscible.

At 1250 K: $2Cu_{(s)} + 1/2O_{2(g)} \rightarrow Cu_2O_{(s)}$;
$\Delta G° = -\ 78,000$ J mol^{-1}

$H_{2(g)} + 1/2O_{2(g)} \rightarrow H_2O_{(g)}$; $\Delta G° = -\ 1,78,000$ J mol^{-1};
G is the Gibbs energy.)

13. Consider the following reversible reaction,

$A_{(g)} + B_{(g)} \rightleftharpoons AB_{(g)}$

The activation energy of the backward reaction exceeds that of the forward reaction by $2RT$ (in J mol^{-1}). If the pre-exponential factor of the forward reaction is 4 times that of the reverse reaction, the absolute value of $\Delta G°$ (in J mol^{-1}) for the reaction at 300 K is ____ .

(Given : ln(2) = 0.7, RT = 2500 J mol^{-1} at 300 K and G is the Gibbs energy)

14. Consider an electrochemical cell :

$A_{(s)} \mid A^{n+}$ (aq, 2 M) $\parallel B^{2n+}$ (aq, 1 M) $\mid B_{(s)}$. The value of $\Delta H°$ for the cell reaction is twice that of $\Delta G°$ at 300 K. If the emf of the cell is zero, the $\Delta S°$ (in J K^{-1} mol^{-1}) of the cell reaction per mole of B formed at 300 K is _____.

(Given: ln(2) = 0.7, R (universal gas constant) = 8.3 J K^{-1}mol^{-1}. H, S and G are enthalpy, entropy and Gibbs energy, respectively).

Section 3 (Maximum Marks : 12)

- *This section contains FOUR (04) questions.*
- *Each question has TWO (02) matching lists: LIST-I and LIST-II.*
- *FOUR options are given representing matching of elements from LIST-I and LIST-II. ONLY ONE of these four options corresponds to a correct matching.*
- *For each question, choose the option corresponding to the correct matching.*
- ***For each question, marks will be awarded according to the following marking scheme:***

Full Marks : +3 *If ONLY the option corresponding to the correct matching is chosen.*

Zero Marks : 0 *If none of the options is chosen (i.e. the question is unanswered).*

Negative Marks : –1 *In all other cases.*

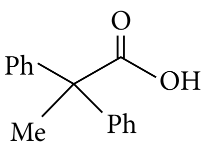
15. Match each set of hybrid orbitals from List-I with complex(es) given in List-II.

List-I	List-II
P. dsp^2	1. $[FeF_6]^{4-}$
Q. sp^3	2. $[Ti(H_2O)_3Cl_3]$
R. sp^3d^2	3. $[Cr(NH_3)_6]^{3+}$
S. d^2sp^3	4. $[FeCl_4]^{2-}$
	5. $Ni(CO)_4$
	6. $[Ni(CN)_4]^{2-}$

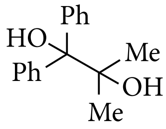
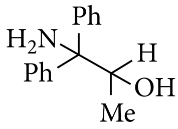
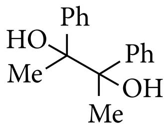
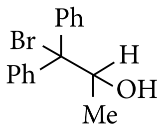
The correct option is

(a) P → 5; Q → 4,6; R → 2, 3; S → 1
(b) P → 5,6; Q → 4; R → 3; S → 1, 2
(c) P → 6; Q → 4, 5; R → 1; S → 2,3
(d) P → 4, 6; Q → 5, 6; R → 1, 2; S → 3

16. The desired product X can be prepared by reacting the major product of the reactions in List-I with one or more appropriate reagents in List-II. (given, order of migratory aptitude: aryl > alkyl > hydrogen)

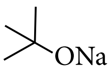
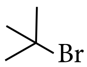
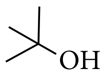
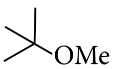
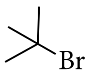
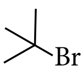
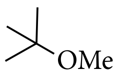
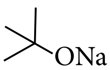
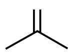
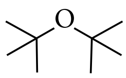


X

List-I		List-II
P. 	$+ H_2SO_4$	1. I_2, NaOH
Q. 	$+ HNO_2$	2. $[Ag(NH_3)_2]OH$
R. 	$+ H_2SO_4$	3. Fehling solution
S. 	$+ AgNO_3$	4. HCHO, NaOH
		5. NaOBr

The correct option is
(a) P → 1; Q → 2, 3; R → 1, 4; S → 2, 4
(b) P → 1, 5; Q → 3, 4; R → 4, 5; S → 3
(c) P → 1, 5; Q → 3, 4; R → 5; S → 2, 4
(d) P → 1, 5; Q → 2, 3; R → 1, 5; S → 2, 3

17. List-I contains reactions and List-II contains major products.

List-I			List-II
P. 	+ 	⟶	1. 
Q. 	+ HBr	⟶	2. 
R. 	+ NaOMe	⟶	3. 
S. 	+ MeBr	⟶	4. 
			5. 

Match each reaction in List-I with one or more products in List-II and choose the correct option.
The correct option is
(a) P → 1, 5; Q → 2; R → 3; S → 4
(b) P → 1, 4; Q → 2; R → 4; S → 3
(c) P → 1, 4; Q → 1, 2; R → 3, 4; S → 4
(d) P → 4, 5; Q → 4; R → 4; S → 3, 4

18. Dilution processes of different aqueous solutions, with water, are given in List-I. The effects of dilution of the solutions on $[H^+]$ are given in List-II.
(Note: Degree of dissociation (α) of weak acid and weak base is $\ll 1$; degree of hydrolysis of salt $\ll 1$; $[H^+]$ represents the concentration of H^+ ions)

List-I	List-II
P. (10 mL of 0.1 M NaOH + 20 mL of 0.1 M acetic acid) diluted to 60 mL	1. The value of $[H^+]$ does not change on dilution
Q. (20 mL of 0.1 M NaOH + 20 mL of 0.1 M acetic acid) diluted to 80 mL	2. The value of $[H^+]$ changes to half of its initial value on dilution
R. (20 mL of 0.1 M HCl + 20 mL of 0.1 M ammonia solution) diluted to 80 mL	3. The value of $[H^+]$ changes to two times of its initial value on dilution
S. 10 mL saturated solution of $Ni(OH)_2$ in equilibrium with excess solid $Ni(OH)_2$ is diluted to 20 mL (solid $Ni(OH)_2$ is still present after dilution).	4. The value of $[H^+]$ changes to $\frac{1}{\sqrt{2}}$ times of its initial value on dilution
	5. The value of $[H^+]$ changes to $\sqrt{2}$ times of its initial value on dilution

Match each process given in List-I with one or more effect(s) in List-II.
The correct option is
(a) P → 4; Q → 2; R → 3; S → 1
(b) P → 4; Q → 3; R → 2; S → 3
(c) P → 1; Q → 4; R → 5; S → 3
(d) P → 1; Q → 5; R → 4; S → 1

ANSWER KEY

Paper-I

1. (b,c)	**2.** (b,c)	**3.** (a,b,c)	**4.** (b)	**5.** (a,b,d)
6. (b,c)	**7.** (1)	**8.** (2992)	**9.** (3)	**10.** (10)
11. (2.22)	**12.** (19)	**13.** (4.47)	**14.** (0.05)	**15.** (c)
16. (a)	**17.** (a)	**18.** (b)		

Paper-II

1. (a,b,d)	**2.** (b,d)	**3.** (d)	**4.** (d)	**5.** (a,d)
6. (a,c)	**7.** (5 or 6)	**8.** (6.47)	**9.** (126)	**10.** (7)
11. (495)	**12.** (–14.6)	**13.** (8500)	**14.** (–11.62)	**15.** (c)
16. (d)	**17.** (b)	**18.** (d)		

For complete solutions refer to MTG JEE Advanced Explorer.

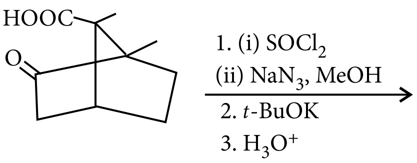
JEE WORKOUTS

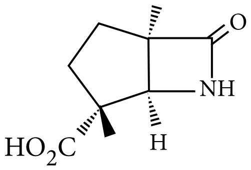
*Arunava Sarkar

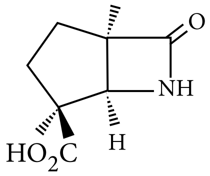
SECTION-1

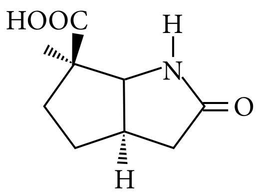
(One or More than One Option Correct)

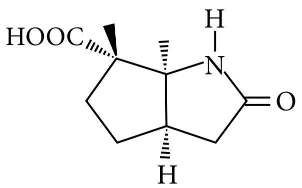
1. Identify the product.



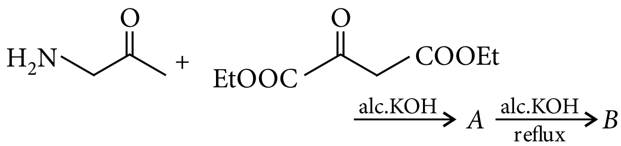
(a) 

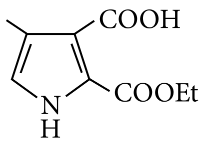
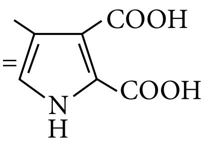
(b) 

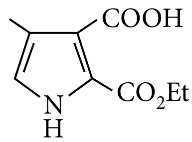
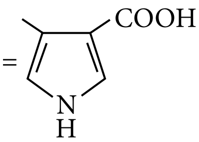
(c) 

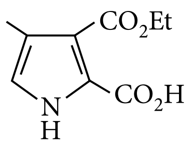
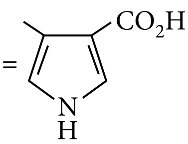
(d) 

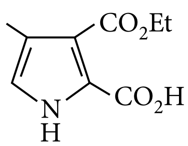
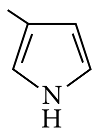
2. The major products A and B in the following reaction sequence are



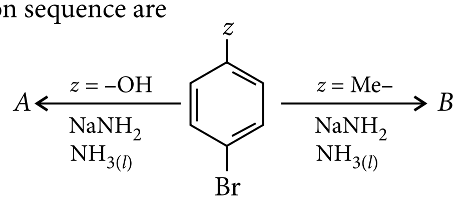
(a) A =  B = 

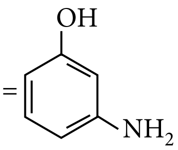
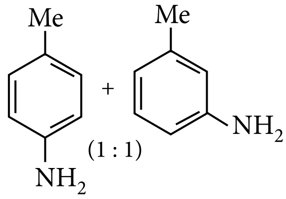
(b) A =  B = 

(c) A =  B = 

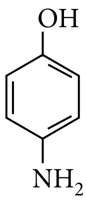
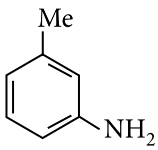
(d) A =  B = 

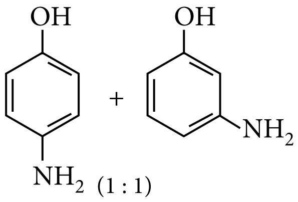
3. The major products A and B in the following reaction sequence are

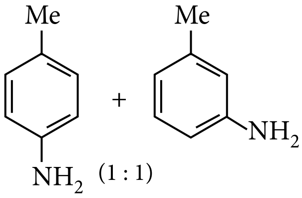


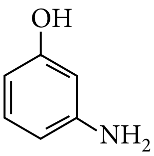
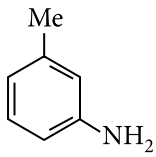
(a) A =  B = 

*Institute of Chemistry (IOC)- Asansol, Durgapur, Dhanbad, Burdwan, Kolkata, Jamshedpur, Bokaro, Patna

(b) $A =$  $B =$ 

(c) $A =$ 

$B =$ 

(d) $A =$  $B =$ 

4. Which of the following thermodynamic relation(s) is/ are correct?

(a) $\left(\frac{\partial P}{\partial V}\right)_S = \left(\frac{\partial P}{\partial S}\right)_V$ (b) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$

(c) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$ (d) $\left(\frac{\partial S}{\partial P}\right)_T = \left(\frac{\partial V}{\partial T}\right)_P$

5. Select the correct statement(s).

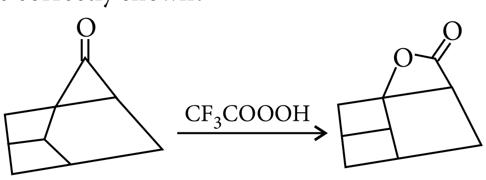
(a) In a mixture of $KMnO_4$ and $H_2C_2O_4$, $KMnO_4$ decolourises faster at higher temperature than lower temperature.

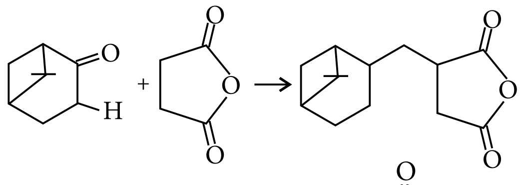
(b) A catalyst participates in a chemical reaction by forming temporary bonds with the reactant resulting in an intermediate complex.

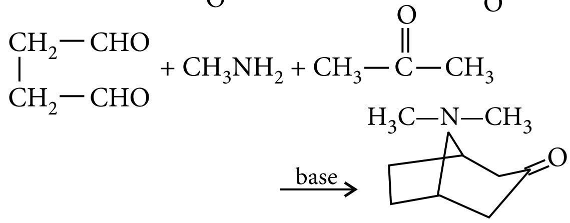
(c) In collision theory, only activation energy determines the criteria for effective collision.

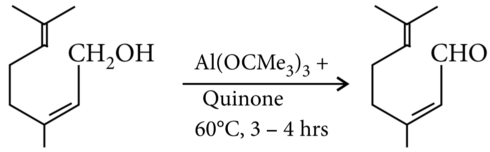
(d) Collision theory assumes molecules to be soft spheres and consider their structural aspects.

6. In how many of the following case(s) product(s) is/are correctly shown?

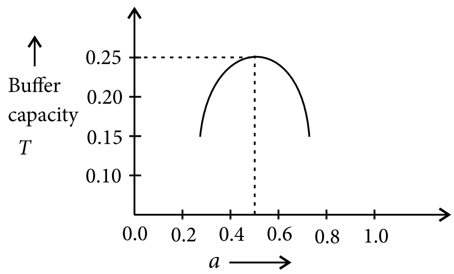
(a) 

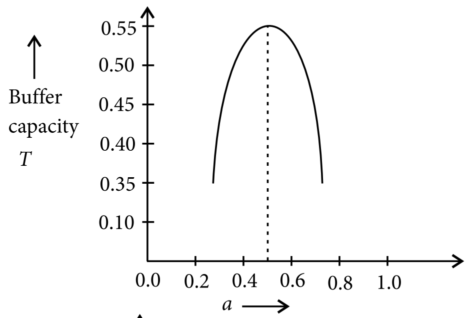
(b) 

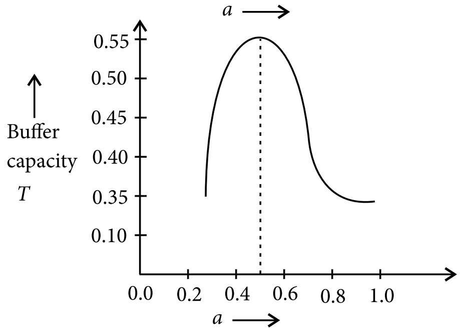
(c) 

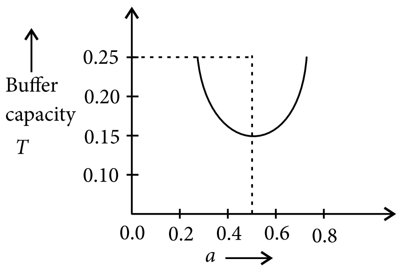
(d) 

7. A buffer solution is prepared by mixing 'a' moles of CH_3COONa and 'b' moles of CH_3COOH such that $(a + b) = 1$, into water to make 1 L buffer solution. If the buffer capacity of this buffer solution is plotted against moles of salt CH_3COONa 'a' then the plot obtained will be (to the scale) approximately (as shown in fig. in options)

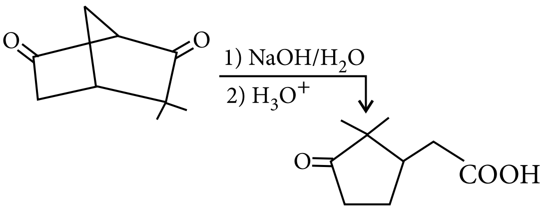
(a) 

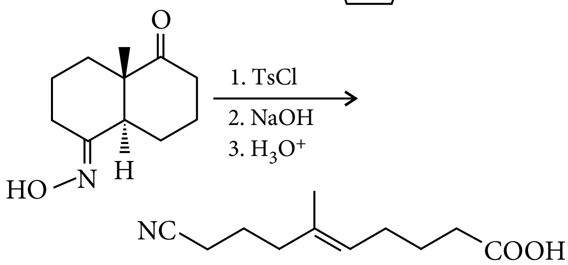
(b) 

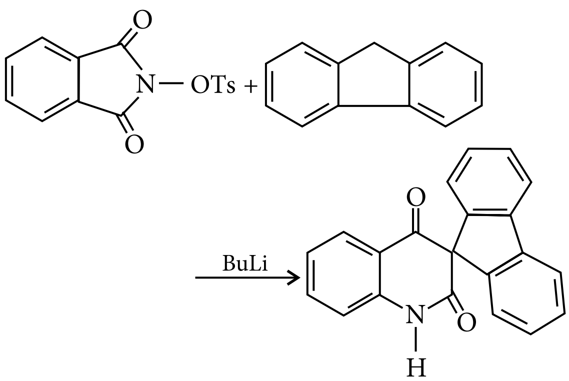
(c) 

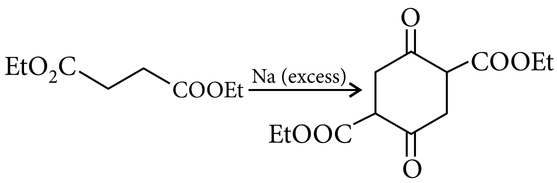
(d) 

8. In how many cases product(s) is/are correctly matched?

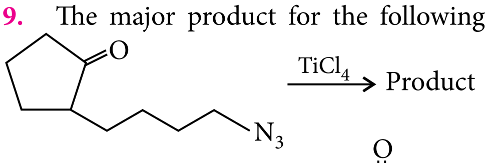
(a) 

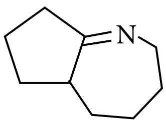
(b) 

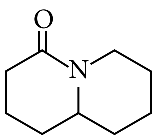
(c) 

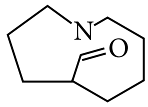
(d) 

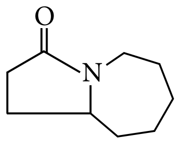
9. The major product for the following reaction is



(a) 

(b) 

(c) 

(d) 

SECTION-2

Numerical Answer Type OR Integer Type

10. At 400 K, the half-life period for the decomposition of a sample of gaseous compound initially at 55.5 kPa was 340 sec. When the pressure was 28.9 kPa the half-life period was 178 sec. What is the order of the reaction?

11. **(a)** $CuSO_4$ reacts with KI in acidic medium to liberate I_2, $2CuSO_4 + 4KI \rightarrow Cu_2I_2 + 2K_2SO_4 + I_2$

(b) Mercuric iodate $Hg_5(IO_6)_2$ reacts with a mixture of KI and HCl as per the following equations :

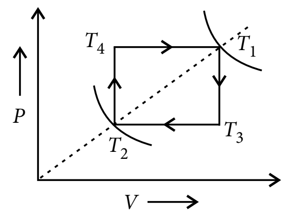
$$Hg_5(IO_6)_2 + 34KI + 24HCl \rightarrow 5K_2HgI_4 + 8I_2 + 24KCl + 12H_2O$$

The liberated iodine is titrated against $Na_2S_2O_3$ solution, 1 mL of which is equivalent to 0.0499 g of $CuSO_4 \cdot 5H_2O$. What volume in mL of $Na_2S_2O_3$ solution will be required to react with I_2 liberated from 0.7245 g of $Hg_5(IO_6)_2$?

Molecular wt. of $Hg_5(IO_6)_2$ = 1448.5 and

Molecular wt.of $CuSO_4{\cdot}5H_2O$ = 249.5

12. Between two isotherms we have a cycle as shown. Find the work done by the gas during the cycle in (J). (Given: T_1 = 127°C; T_2 = 16°C, n = 1 mole)



13. A sample weighing 0.3 g contains $K_3[Fe(C_2O_4)_3]{\cdot}3H_2O$, $FeCl_3 \cdot 6H_2O$ and inert impurity is dissolved in dil. H_2SO_4 and volume made upto 100 mL. A 20 mL portion of this solution required 3.75 mL of 0.005 M acidified $KMnO_4$ solution to reach the equivalence point. In an another experiment 50 mL sample of the same stock solution is treated with Zn-amalgam and the resulting solution required 17.5 mL of permanganate solution of same strength. If mass percentage of $FeCl_3 \cdot 6H_2O$ in the original sample is x, then find x.

SECTION-3

Comprehension Type

In three dimension, wave function may be expressed in spherical co-ordinate system (r, θ, ϕ) :

r = distance of electron from the nucleus
θ = angle from z-axis, varying from 0 to π
ϕ = angle from x axis, varying from 0 to 2π
ψ may be represented as $\psi(r, \theta, \phi) = R(r), A(\theta, \phi)$
The $R(r)$ is determined by n and l. Then $A(\theta, \phi)$ is determined by l and m.

14. Which of the following is $R(r)$ part of $3p$ atomic orbital of hydrogen atom? (Given : a_0 = 0.529 Å)

(a) $\dfrac{2}{(a_0)^{3/2}} \cdot e^{-r/a_0}$

(b) $\dfrac{2}{27}\left(\dfrac{1}{3a_0}\right)^{3/2}\left(27 - 18\dfrac{r}{a_0} + 2\dfrac{r}{a_0^2}\right) \cdot e^{-r/3a_0}$

(c) $\dfrac{2}{(2a_0)^{3/2}}\left(2 - \dfrac{r}{a_0}\right) \cdot e^{-r/2a_0}$

(d) $\dfrac{1}{81\sqrt{3}}\left(\dfrac{2}{a_0}\right)^{3/2}\left(6 - \dfrac{r}{a_0}\right) e^{-r/3a_0}$

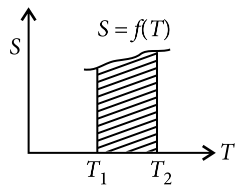
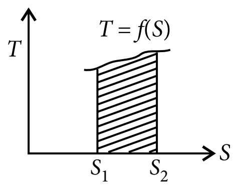
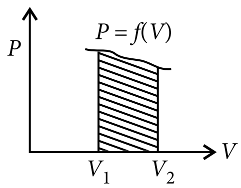
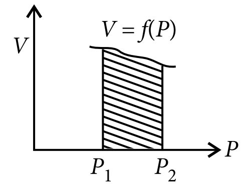
15. Angular part of H atom wave equation $A(\theta, \phi) = \dfrac{1}{\sqrt{4\pi}}$. Hence atomic orbital is

(a) d_{xz} (b) p_x (c) p_y (d) s

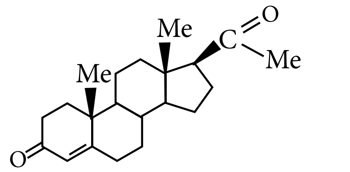
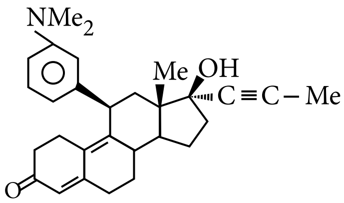
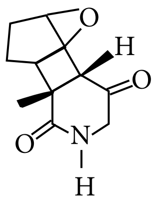
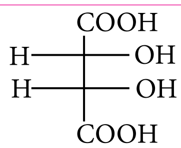
SECTION-4

Column Matching Type

16. Match the following :

	Column-1 (Graph)		Column-2 (Area represents magnitude of)
A.		p.	q
B.		q.	W
C.		r.	$(\Delta G)_T$
D.		s.	$(\Delta G)_P$

17. Match the following :

	Column-1 (Molecule)		Column-2 (Property)
A.		p.	Meso compound
B.		q.	Compound having even number of chiral centres
C.		r.	Optically active compound
D.		s.	Compound having odd number of chiral centres

18. One mole of $N_{2(g)}$ is taken in 1 litre empty container fitted with a movable piston at 300 K. If it is heated to 1200 K at constant pressure then match the change (Column-2) with parameters (Column-1) of gas as compared to initial state.

	Column-1 (Parameter)		Column-2 (Change)
A.	Z_1(Number of collisions made by a molecule per unit time)	p.	1/8
B.	Z_{11} (Collision frequency)	q.	2
C.	λ (Mean free path)	r.	1/2
D.	U_{rms} (Root mean square speed)	s.	4

Solutions will be published in next issue.

CHEMISTRY MUSING

SOLUTION SET 59

1. (b) : Pentyne-1 $\rightleftharpoons$ Pentyne-2 + 1, 2-pentadiene

	(A)	(B)	(C)
% at eq.	1.3	95.2	3.5

$$K_{eq} = \frac{[B][C]}{[A]} = \frac{95.2\times 3.5}{1.3} = 256.31$$

For $B \rightleftharpoons A$; $\Delta G_1^\circ = ?$

$$K_1 = \frac{[A]}{[B]} = \frac{[C]}{K_{eq}} = \frac{3.5}{256.31} = 0.014$$

then, $\Delta G_1^\circ = -2.303RT \log K_1$

$= -2.303 \times 8.314 \times 448 \log 0.014 = 15869$ J $= 15.869$ kJ

For $B \rightleftharpoons C$; $\Delta G_2^\circ = ?$

$$K_2 = \frac{[C]}{[B]} = \frac{K_{eq}[A]}{[B]^2} = \frac{256.31\times 1.3}{(95.2)^2} = 0.037$$

then, $\Delta G_2^\circ = -2.303RT \log K_2$

$= -2.303 \times 8.314 \times 448 \log 0.037 = 12266$ J $= 12.266$ kJ

2. (b) : The given reaction sequence suggest the following :

$$\underset{(A)}{} \xrightarrow{\text{Reductive ozonolysis}} \underset{(B)}{RCHO} + \underset{(C)}{R'CHO}$$

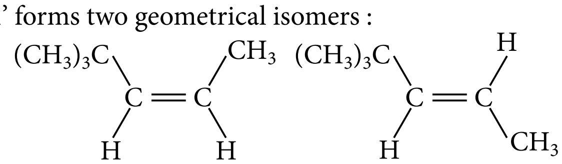
(B) cannot be HCHO because, then (A) must have $R'CH{=}CH_2$ structure which will not give geometrical isomer.

$$\underset{(X)}{C_7H_{12}} \xrightarrow[CH_3COOH]{B_2H_6} \underset{(A)}{C_7H_{14}}$$

The reaction of alkyne takes place through boron hydride to give almost pure alkene.

$$\underset{(X)}{(CH_3)_3C - C{\equiv}C - CH_3} \xrightarrow[CH_3COOH]{B_2H_6} \underset{(A)}{(CH_3)_3C - CH{=}CH - CH_3}$$

'A' forms two geometrical isomers :



cis-alkene (A–1)   *trans*-alkene (A–2) (more stable)

'A' on reductive ozonolysis gives 'B' and 'C'.

$$\underset{(A)}{(CH_3)_3C - CH{=}CH - CH_3} \xrightarrow{\text{Reductive ozonolysis}} \underset{(B)}{(CH_3)_3C - CHO} + \underset{(C)}{CH_3CHO}$$

(B) does not have α-H atom so, it will show Cannizzaro reaction.

3. (c) : Volume of cylindrical particle (V)

$$= \pi r^2 h = (3.14)\left(\frac{100\,\text{Å}}{2}\right)^2 (4000\,\text{Å})$$

$= 3.14 \times 10^7$ (Å)$^3 = 3.14 \times 10^{-17}$ cm^3

∵ The specific volume of virus = 0.314 cm^3 g^{-1} (given)

If the volume is 3.14×10^{-17} cm^3, then weight per molecule is

$$= \left(\frac{1}{0.314\ \text{cm}^3\text{g}^{-1}}\right)(3.14\times10^{-17}\,\text{cm}^3) = 10^{-16}\,\text{g molecule}^{-1}$$

∴ Molecular weight of virus =

$$(10^{-16}\ \text{g molecule}^{-1})\left(\frac{6.02\times10^{23}\,\text{molecules}}{1\ \text{mol}}\right)$$

$= 6.02 \times 10^7$ g mol^{-1}

4. (c) : For Fe/Fe^{2+} in H^+ medium :

$Fe \longrightarrow Fe^{2+} + 2e^-$; $\quad E^\circ_{ox} = 0.4$ V

$2H^+ + 2e^- \longrightarrow H_2$; $\quad E^\circ_{Red} = 0$ V

∴ $Fe + 2H^+ \longrightarrow Fe^{2+} + H_2$; $\quad E^\circ_{cell} = 0.4$ V

Similarly, E°cell for Mn^{2+}/Mn and Cr^{2+}/Cr in acidic medium will be 1.2 V and 0.9 V respectively. Thus, tendency to get oxidised is in the order :

Mn > Cr > Fe

5. (b) : Case I: Using eriochrome black-T as indicator.

Molarity of EDTA solution $= \dfrac{0.093\times1000}{372\times250} = 0.001$ M

Volume of EDTA used = 10 mL

Volume of water sample = 10 mL

M_1V_1(EDTA) $= M_2V_2$ (Ca^{2+} and Mg^{2+} in hard water)

$0.001 \times 10 = M_2 \times 10$

$M_2 = 0.001$

∴ Molarities of ($Ca^{2+} + Mg^{2+}$)ions = 0.001 M

= 1.0 mmoles L^{-1}

Case II: Using murexide as indicator.

M_1V_1(EDTA) $= M_2V_2$ (Hard water)

$0.001 \times 10 = M_2 \times 40$

$M_2 = 0.25 \times 10^{-3} = 0.25$ mmol L^{-1}

∴ Total mmol L^{-1} of Ca^{2+} and Mg^{2+} = 1.0

(Murexide indicator is used for measurement of calcium ions.)

∴ mmoles L^{-1} of Ca^{2+} = 0.25

mmoles L^{-1} of Mg^{2+} = 1.0 – 0.25 = 0.75

∴ Amount of Ca^{2+} ⇒ $0.25 \times 40 \times 10^{-3} = 0.01$ g L^{-1}

Amount of Mg^{2+} ⇒ $0.75 \times 24 \times 10^{-3} = 0.018$ g L^{-1}

6. (1.17) : $N_2O_4 \rightleftharpoons 2NO_2$

Let a mole of N_2O_4 and b mole of NO_2 were present in equilibrium mixture.

$$\therefore\ (a+b)=\frac{PV}{RT}=\frac{753\times0.5}{760\times0.0821\times298}=0.020 \qquad \text{...(i)}$$

$$K_p=\frac{(n_{NO_2})^2}{(n_{N_2O_4})}\times\left[\frac{P}{n_{NO_2}+n_{N_2O_4}}\right]$$

$$\therefore\ 0.113=\frac{b^2}{a}\times\left[\frac{753}{760\times(a+b)}\right]$$

$$\therefore\ \frac{b^2}{a(a+b)}=0.114 \qquad \text{...(ii)}$$

By eqs. (i) and (ii)

$$\therefore\ \frac{b^2}{a}=0.114\times0.020=2.3\times10^{-3} \qquad \text{...(iii)}$$

$b^2 = 2.3 \times 10^{-3}\, a = 2.3 \times 10^{-3} \times (0.02 - b)$

or $b^2 + 0.0023\, b - 4.6 \times 10^{-5} = 0$

$$\therefore\ b=-\frac{0.0023\pm\sqrt{(0.0023)^2+4\times4.6\times10^{-5}\times1}}{2\times1}$$

$$=\frac{-0.0023\pm\sqrt{1.90\times10^{-4}}}{2}=5.73\times10^{-3}$$

$\therefore$ By Eq. (i) $\qquad a = 0.014$

$2NO_{2(aq)} + 2H_2O_{(l)} \rightarrow HNO_{2\,(aq)} + H_3O^+_{(aq)} + NO^-_{3\,(aq)}$

Total NO_2 moles = $5.73 \times 10^{-3} + 2 \times$ moles of N_2O_4

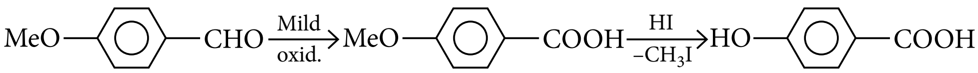
$= 5.73 \times 10^{-3} + 2 \times 0.014 = 0.0337$

$2NO_{2(aq)}$ + $2H_2O_{(l)}$ →	$HNO_{2\,(aq)}$ +	$H_3O^+_{(aq)}$ +	$NO^-_{3\,(aq)}$
0.0337	0	0	0
0	$\frac{0.0337}{2}$	$\frac{0.0337}{2}$	$\frac{0.0337}{2}$

$$[H^+]=\frac{0.337\times1000}{2\times250}=0.0674\text{ M}$$

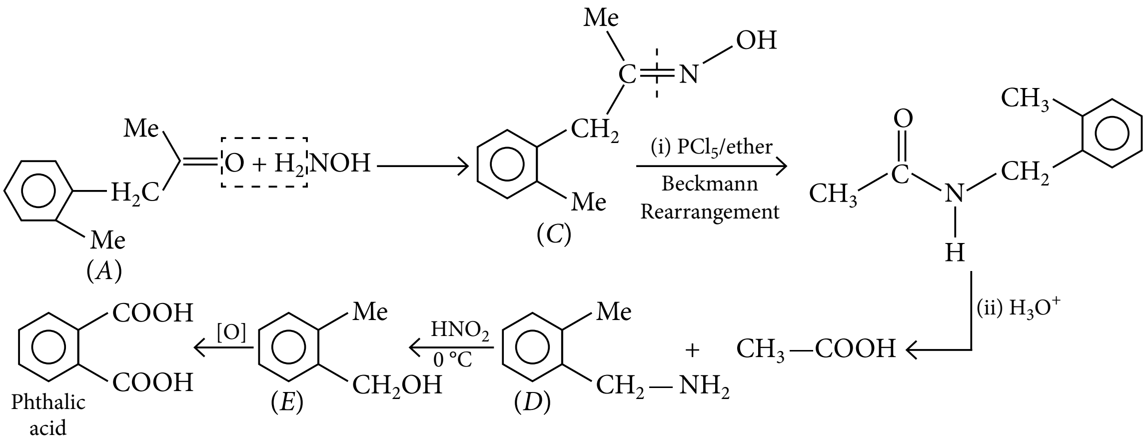
Also, $\quad pH = -\log[H^+] = -\log 0.0674 = 1.17$

7. (b) :



$(C_8H_8O_2)$ (B) $\qquad$ $(C_8H_8O_3)$ (F)

8. (c) : As compound '*A*' shows positive iodoform test so, it can be



9. (4) : Volume of the unit cell = $(5 \times 10^{-8}\text{ cm})^3$

$= 1.25 \times 10^{-22}\text{ cm}^3$

Density of FeO = 4.0 g cm^{-3}

Mass of unit cell = $1.25 \times 10^{-22}\text{ cm}^3 \times 4.0\text{ g cm}^{-3}$

$= 5.0 \times 10^{-22}$ g

$$\text{Mass of one molecule of FeO}=\frac{\text{Molar mass in grams}}{\text{Avogardro's number}}$$

$$=\frac{72\text{ g mol}^{-1}}{6.022\times10^{23}\text{ mol}^{-1}}=1.196\times10^{-22}\text{ g}$$

$\therefore$ Number of FeO molecules per unit cell

$$=\frac{5.0\times10^{-22}\text{ g}}{1.196\times10^{-22}\text{ g}}=4.18\approx4$$

Thus, there are four Fe^{2+} ions and four O^{2-} ions in each unit cell.

10. (7) :

	$K_4[Fe(CN)_6]$ ⇌	$4K^+$ +	$[Fe(CN)_6]^{4-}$
Initial moles	1	0	0
After dissociation	1 – 0.45 = 0.55	4 × 0.45	0.45

Total moles after dissociation (i) = 0.55 + 1.8 + 0.45

= 2.8

Osmotic pressure (π) = $iCRT$

$= (2.8) \times (0.1\text{ mol dm}^{-3})(0.0821\text{ dm}^3\text{ atm K}^{-1}\text{ mol}^{-1})(300\text{ K})$

$= 6.89 \approx 7$ atm

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